FLORIDA GEOLOGICAL SURVEY

FOURTH ANNUAL REPORT

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FLORIDA STATE GEOLOGICAL SURVEY.

E. H. SELLARDS, State Geologist

Fourth Annual Report
1910-11

ADMINISTRATIVE REPORT AND ACCOMPANYING PAPERS

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PUBLISHED FOR
THE STATE GEOLOGICAL SURVEY
TALLAHASSEE, 1912

LETTER OF TRANSMITTAL.

To His Excellency, Hon. Albert W. Gilchrist,
Governor of Florida.

Sir—In accordance with the Survey Law I submit herewith a report of the progress of investigations made by the Geological Survey for the year ending June 30, 1911.

Very respectfully,
E. H. Sellards,
State Geologist.

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FLORIDA STATE GEOLOGICAL SURVEY.

E. H. SELLARDS, STATE GEOLOGIST.

ADMINISTRATIVE REPORT.

The members of the State Survey during the past year have been, in addition to the State Geologist, Mr. Herman Gunter, and during a part of the year Dr. R. M. Harper. The chemical analyses necessary to the work of the State Survey are made by the State Chemist.

Mr. Gunter has assisted in the preparation of the paper on the artesian water supply of west Florida. In addition he has had charge of cataloging and recording the Survey collections.

Dr. Harper completed the preparation of a preliminary paper on the peat resources of the State. The paper was published in the Third Annual Report, 1910.

In addition to the necessary correspondence and administrative work of the office, the State Geologist has prepared a paper on the soils of the State and on the artesian water supply of west-central and west Florida.

PUBLICATIONS ISSUED.

The Third Annual Repprt, covering the operations of the Survey to June 30, 1910, was issued during the year. In addition to this report a bulletin was published on the roads and road materials of the State.

PUBLICATIONS AVAILABLE FOR DISTRIBUTION.

The following is a list of the publications issued by the State Geological Survey since its organization and now available for distribution:

1. First Annual Report, 1908, **114 pp., 6 pls.**

This report contains: (1) a sketch of the geology of Florida; (2) a chapter on mineral industries, including phosphate, kaolin or ball clay, brick-making clays, fullers earth, peat, lime and cement and road-making materials; (3) a bibliography of publications on

Florida geology, with a review of the more important papers published previous to the organization of the present Geological Survey.

2. Second Annual Report, 1909, 299 pp., 19 pls., 5 text figs., one map.

This report contains: (1) A preliminary report on the geology of Florida, with special reference to the stratigraphy, including a topographic and geologic map of Florida, prepared in co-operation with the United States Geological Survey; (2) the topography and geology of Southern Florida; (3) mineral industries; (4) the fullers earth deposits of Gadsden County, with notes on similar deposits found elsewhere in the State.

3. Third Annual Report, 1910, 397 pp., 28 pls., 30 text figs.

This report contains: (1) A preliminary paper on the Florida phosphate deposits; (2) some Florida lakes and lake basins; (3) the artesian water supply of eastern Florida; (4) a preliminary report on the Florida peat deposits.

4. Fourth Annual Report, 1912, 175 pp., 16 pls., 15 text figs., one map.

This report contains: (1) The soils and other surface residual materials of Florida, their origin, character and the formations from which derived; (2) the water supply of west-central and west Florida; (3) the production of phosphate rock in Florida during 1910 and 1911.

5. Bulletin No. 1. The Underground Water Supply of Central Florida, 1908, 103 pp., 6 pls., 6 text figs.

This Report contains: (1) Underground water; general discussion; (2) the underground water of central Florida, deep and shallow wells, spring and artesian prospects; (3) effects of underground solution, cavities, sink-holes, disappearing streams and solution basins; (4) drainage of lakes, ponds and swamp lands and disposal of sewage by bored wells; (5) water analyses and tables giving general water resources, public water supplies, spring and well records.

6. Bulletin No. 2. Roads and Road Materials of Florida, 1911, 31 pp., 4 pls.

DISTRIBUTION OF REPORTS.

The reports issued by the State Survey are distributed upon request, and may be obtained free by addressing the State Geologist, Tallahassee, Fla.

THE PURPOSE AND DUTIES OF THE STATE GEOLOGICAL SURVEY.

Among the specific objects for which the Survey exists, as stated in the enactment, is that of making known information regarding the minerals, water supply and other natural resources of the State, including the occurrence and location of minerals and other deposits of value, surface and subterranean water supply and power and mineral waters and the best and most economic methods of development, together with analysis of soils, minerals and mineral waters, with maps, charts and drawings of the same.

A distinctly educational function of the Survey is indicated by Section 4 of the law, which makes it the duty of the State Geologist to make collections of specimens, illustrating the geological and mineral features of the State, duplicate sets of which shall be deposited with each of the State colleges. The publication of annual reports is provided for as a means of disseminating the information obtained in the progress of the Survey.

The Survey is thus intended to serve on the one hand an economic, and on the other an educational purpose.

In its economic relations a State Survey touches on very varied interests of the State's development. In its results it may be expected, judging from the experience of similar surveys in other States, to contribute not so much to sensational or sudden development of geat mineral deposits as to an intelligent development of the State's natural resources. Its educational value is of no less immediate concern to the State, both to the citizens within the State and to prospective citizens without.

A knowledge of the soil and of the available water supply is very necessary to successful agriculture, and the Survey's investigations along these lines are of value to all landowners. A knowledge of the mineral deposits, which may lie beneath the surface, is likewise necessary to a correct valuation of land. The relation of the State Survey to the ownership of mineral lands is specifically defined. The Survey law provides that it shall be the duty of the State Geologist and his assistants, when they discover any mineral deposits or substances of value, to notify the owners of the land upon which such deposits occur before disclosing their location to any other person or persons. Failure to do so is punishable by fine and imprisonment. It is not intended by the law, however, that the State Geologist's time shall be devoted to examinations and reports upon the value of private mineral lands. Reports of this character are properly the province of commercial geologists, who may be employed by owners of land for that purpose. To accomplish the best results, the work of the Survey must be in accordance with definite plans by which the State's resources are investigated in an orderly manner. Only such examinations of private lands can be made as constitute a part of the regularly planned operations of the Survey.

SAMPLES SENT TO THE SURVEY FOR EXAMINATION.

Samples of rocks, minerals and fossils will be at all times gladly received, and reported upon. Attention to inquiries and general correspondence are a part of the duties of the office, and afford a means through which the Survey may in many ways be useful to the citizens of the State.

The following suggestions are offered for the guidance of those submitting samples:

1. The exact location of all samples should be given. This should be carefully written out in full and placed on the *inside* of the package.

2. The statement accompanying the samples should give the conditions under which the specimen occurs, whether an isolated fragment or part of a larger mass or deposit.

3. Each package should be addressed to the Florida State Geological Survey, Tallahassee. The name and address of the sender should be plainly written on the outside.

4. Transportation charges, whether by mail, express or freight, should in all cases be prepaid.

THE COLLECTION OF STATISTICAL INFORMATION.

For many purposes the collection and publication of statistical information is helpful, both to the industries concerned and to the general public. Such statistical information is desired from all the mineral industries of the State. Such information will be recognized as strictly confidential, in so far as it relates to the private business of any individual or company, and will be used only in making up State and County totals. The co-operation of the various industries of the State is invited in order that the best possible showing of the State's products may be made annually.

FINANCIAL STATEMENT FOR THE YEAR ENDING JUNE 30, 1911.

The total appropriation for the State Geological Survey is $7,500 per annum. With the exception of the salary of the State Geologist, the amount of which is fixed by statute, all Survey accounts are paid upon warrants issued by the Comptroller as per itemized vouchers approved by the Governor. The following is a list of the expenses of the Survey for the year ending June 30, 1911. The original of all bills and the itemized statements of all expense accounts are on file in the office of the Comptroller. Duplicate copies of the same are on file in the office of the State Geologist:

LIST OF WARRANTS ISSUED DURING THE YEAR ENDING JUNE 30, 1911.

July, 1910.	
Herman Gunter, Assistant, salary July, 1910	$ 100.00
R. M. Harper, Asst., salary July 1-15, 1910, (one-half mo.)	50.00
H. & W. B. Drew Company, supplies	4.60
August, 1910.	
E. H. Sellards, State Geologist, expenses, August, 1910	6.25
Herman Gunter, Assistant, salary, August, 1910	100.00
R. M. Harper, Assistant, salary, August 1910	100.00
Southern Express Company	3.81
September, 1910.	
E. H. Sellards, State Geologist, salary for quarter ending September 30, 1910.	625.00
E. H. Sellards, State Geologist, expenses, Sept. 1910	59.33
Herman Gunter, Asst., salary (100.00),expenses (61.10) September, 1910.	161.10
R. M. Harper, Asst., salary (100.00), expenses (31.18), September, 1910.	131.18
D. R. Cox Furniture Company, index cards	2.18
H. & W. B. Drew Company, supplies	8.88
October, 1910.	
Herman Gunter, Assistant, salary, October, 1910	100.00
Southern Express Company	8.44
W. W. Trammell, rent of typewriter	6.00
Maurice-Joyce Engraving Company, engravings	176.89
T. J. Appleyard, printing	6.00
John McDougall, postage	50.00
November, 1910.	
E. H. Sellards, State Geologist, expenses, Oct. and Nov. 1910	50.10
Herman Gunter, Asst., salary, November, 1910	100.00
R. M. Harper, Assistant, salary, 1910	100.00
The Science Press, publications	3.00
December, 1910.	
E. H. Sellards, State Geologist, salary for quarter ending December 31, 1910	625.00
E. H. Sellards, State Geologist, expenses, Dec. 1910	51.69
Herman Gunter, Asst., salary (100.00),expenses (63.65), December, 1910.	163.65
N. H. Cox, Asst., salary, July, August and September	125.00
Ada Moore, stenographic services	5.75
Dan Allen, freight and drayage	1.90
Southern Express Company	10.58
American Journal Science, subscription	6.00
Engineering and Mining Journal, subscription	5.00
January, 1911.	
E. H. Sellards, State Geologist, expenses, January, 1911	80.90
Herman Gunter, Asst., expenses, January, 1911	72.87
E. Gunter, clerical services, January, 1911	40.00
John McDougall, postage	108.50
Dan Allen, freight and drayage	38.52
H. & W. B. Drew Company, typewriter and supplies	105.06
February, 1911.	
E. Gunter, clerical services, February, 1911	8.75
Ada Moore, stenographic services	7.50
John McDougall, postage	100.00

Dan Allen, freight and drayage	23.73
The Phosphate Industry, subscription	6.00
American Journal Science, index to	1.00
Ginn and Company, publications	2.34
Board of Managers, City Water and Light Plants, electric bulbs	3.45
Macmillan Company, publications	4.34
The E. O. Painter Printing Company, printing	548.00
March, 1911.	
E. H. Sellards, State Geologist, salary for quarter ending March 31, 1911	625.00
E. H. Sellards, State Geologist, expenses, March, 1911	47.25
Herman Gunter, Asst., salary for quarter ending March 31, 1911	300.00
Herman Gunter Asst., expenses, March, 1911	67.65
Ada Moore, stenographic services, March, 1911	40.00
Dan Allen, freight and drayage	12.29
D. R. Cox Furniture Company, office furniture	69.50
John McDougall, postage	50.00
Southern Express Company	8.63
April, 1911.	
Ada Moore, services as stenographer	13.80
John McDougall, postage	5.00
T. J. Appleyard, printing	8.00
E. O. Painter Printing Company, printing	1,002.51
Wrigley Engraving and Electrotype Co., engravings	10.00
Dan Allen, freight and drayage	9.58
Southern Express Company	3.50
May and June, 1911.	
E. H. Sellards, State Geologist, salary for quarter ending June 30, 1911	625.00
E. H. Sellards, State Geologist, expenses, April, May, and June, 1911	64.10
Herman Gunter, Asst., salary for quarter ending June 30, 1911	300.00
Herman Gunter, Asst., expenses for April, May, June, 1911	56.70
Ada Moore, stenographic services	27.50
John McDougall, postage	109.96
Munson Supply Company, supplies	3.50
American Institute of Mining Engineers, publications	6.00
McGraw-Hill Book Company, publications	15.50
University of Chicago Press, subscription	3.00
Economic Geology Publishing Company, subscription	3.00
The Record Company, printing	97.90
Southern Express Company	3.91
Total expenditures	$7,687.07
Balance available from preceding year	186.97
Annual appropriation	7,500.00
Overdrawn	.10
	$7,687.07

THE SOILS AND OTHER SURFACE RESIDUAL MATERIALS OF FLORIDA.

Their Origin, Character and the Formations from which Derived.

A STUDY IN AGROGEOLOGY.

By E. H. Sellards.

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THE SOILS AND OTHER SURFACE RESIDUAL MATERIALS OF FLORIDA

E. H. SELLARDS

INTRODUCTION.

FORMATIONS FROM WHICH THE SOILS OF FLORIDA ARE DERIVED.

The following classification and description of the formations in Florida is adapted from the First and Second Annual Reports of the Survey with such additions as subsequent investigations have justified. In this brief review of the geology of the State it will be convenient to describe the various formations in chronological order beginning with the oldest or first formed. In this manner the systematic arrangement of the formations is more readily kept in mind.

The major divisions of geologic time are in order: Archeozoic, Proterozoic, Paleozoic Mesozoic, and Cenozoic. All of the formations of Florida are included in the latest of these major divisions, the Cenozoic.

The geologic periods represented in Florida are the Oligocene, Miocene, Pliocene, Pleistocene and Recent. The formations found in the State are listed in the table on page 9, and are briefly described in subsequent pages of the report.

OLIGOCENE.

The Oligocene, the earliest period recognized in Florida, includes two main divisions known as Lower and Upper Oligocene respectively. The Lower Oligocene includes the Vicksburg Limestone, which is the basal formation underlying Florida, and which from its great thickness and diversity in fauna and lithologic characters has sometimes been referred to as the Vicksburg Group of Limestones. The Upper Oligocene includes the Tampa, Hawthorne. Chattahoochee, and Alum Bluff formations, known collectively as the Apalachicola Group.

LOWER OLIGOCENE.

THE VICKSBURG LIMESTONE.

The Vicksburg Limestone is an extensive formation, which, although exposed over only a limited area, underlies the entire State. As a formation it is not confined to Florida, but extends into Georgia, Alabama, Louisiana and Mississippi, being exposed at the surface or reached by well borings over parts of each of these States. In literature the reader will find the terms Marianna, Peninsular, and Ocala limestones used for phases of the Vicksburg formation. Some doubt remains as to whether these terms apply to actual well marked divisions of the Vicksburg, or merely to varying phases of that formation. In its relation to soils it will not be necessary to describe separately these subdivisions of the formation.

While the Vicksburg Limestone varies in its lithologic characters it is prevailingly light colored and highly fossiliferous. As a rule it is a soft white limestone which crumbles easily and has a granular appearance. Locally, however, it may be close grained, compact and hard, and may be dull colored, or have a pinkish cast.

Locally, also, the formation contains masses or layers of flint. These often occur as "hog backs" in the formation giving much difficulty in mining the rock, and in drilling wells. The flint as well as the compact phase of the limestone is due to deposition from solution by underground water. At Marianna, the type locality of the "Marianna" phase of the formation, the limestone is particularly soft and is there sawed into blocks of convenient size, as taken from the earth, and is used for chimneys and for building purposes. Upon exposure the limestone hardens. This is due to the fact that the water filling the interstices of the rock holds calcium carbonate in solution and this is precipitated as the water evaporates, and acting as a cement, hardens the rock.

The formations which lie above the Vicksburg rest unconformably upon it apparently indicating erosion of this formation previous to the deposition of the later formations. In addition to these irregularities there are further irregularities from subsequent erosion due to solution by underground water. This dissolving effect of underground water is continuously operating. Where the limestone lies near the surface the results are observed in solution basins, underground cavities, and numerous sinks.*

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*For a description of the lake basins formed by solution, see Third Annual Report, pages, 43-76, 1910. A description of the sinks, underground channels and disappearing streams will be found in Bulletin No. 1 of the Survey Report, 1908.

TABLE OF GEOLOGICAL FORMATIONS IN FLORIDA.

	Period.	Formation.	Lithologic Description of the Formation.
CENOZOIC.	Recent......		Sand dunes. Shell mounds. Beach Sands. Coquina. Lacustrine deposits. Chemical deposits. Alluvial deposits. Muck and Peat. Residual material.
	Pleistocene...	Anastasia formation......	Coquina.
		Palm Beach limestone....	Light colored limestone, with sandy beds and loose sand.
		Miami oolite..............	Light gray to white oolitic limestone, sandy in places.
		Key Largo limestone.....	Coralline limestone; reef rock.
		Key West oolite..........	Light gray to white oolitic limestone.
		Lostmans River limestone	Dark to light, hard to friable limestone, sandy or marly in places.
		Unclassified clayey sands and sandy clays of Pliocene or Pleistocene age.	
	Pliocene......	Dunnellon formation.....	Hard rock phosphate.
		Bone Valley gravel.......	Light colored gravel and marl containing phosphatic pebbles.
		Alachua clay.............	Greenish sandy clay, weathering yellow or red.
		Nashua Marl.............	Light colored sandy shell marl.
		Caloosahatchee marl......	Light colored sandy shell marl.
	Miocene......	Choctawhatchee marl (W. Florida and St. Johns Valley)	Greenish to light gray sandy shell marl or greenish gray clay.
		Jacksonville formation (East Coast)	Light gray to white limestone, weathering light yellow. Light gray to yellow clay and gray sand. Some chert beds.
	Oligocene.....	Alum Bluff formation....	Gray to green sands, fossiliferous marls, clays and fullers earth.
		Hawthorne formation (Central Florida).	Yellow limestones, often phosphatic. Greenish or reddish sands. Green clays.
		Chattahoochee formation (West Florida).	Light yellow to gray earthy and siliceous limestones, sometimes cherty. Sand and clay rare.
		Tampa formation (South Florida).	Yellow limestones and greenish clays. Some chert nodules and layers.
		Vicksburg formation.....	Soft, porous, light gray to white limestone containing marl beds and layers of chert.

The interstices and cavities of the rocks below the water line are filled with water, the limestone being an important water-bearing formation.

The areas in which the soils are derived solely from the Vicksburg are limited in extent, yet through the drainage and other conditions arising from the presence of this formation the soils are modified over large areas in the central part of peninsular Florida, as well as in parts of the westward extension of the State.

In western Florida the Vicksburg formation is exposed at the surface in places in the northern part of Jackson, Washington, Holmes and Walton Counties. In Jackson County the exposures are extensive along the Chipola River from near the north line of the State to several miles below Marianna. From the Chipola River west to Holmes Creek the Vicksburg lies near the surface and is locally exposed at the surface. Along the northern border of the State surface exposures occur as far west as the Natural Bridge in the northeastern part of Walton County. The southern line of surface exposure in western Florida is thus seen to extend from Natural Bridge in Walton County in a southeasterly direction, reaching its greatest southward extension along the tributaries of Holmes Creek in Washington County and the Chipola River in Jackson County. From the Chipola River the line of surface exposure bends northeast, crossing the Chattahoochee River above its union with the Flint River.

To the southwest, south, and southeast of this line the Vicksburg dips beneath later formations. At Pensacola the Vicksburg has not been reached by wells exceeding 1,000 feet in depth. As Pensacola is less than 100 miles southwest of the nearest surface exposure of the Vicksburg in Walton County a dip is indicated exceeding an average of ten feet to the mile in that direction. Although well exposed along the Chipola River in Jackson County for some miles above and below Marianna, yet directly east of Marianna the formation is not reached by the Apalachicola, notwithstanding the fact that this river cuts deeper than the Chipola River. The formation is found, however, along the Chattahoochee River, a tributary of the Apalachicola, northeast of Marianna.

Beyond the limits of the surface exposure of this formation its influence is still evident in the formation of occasional sink holes and circular lakes, of which the lake at DeFuniak Springs is an illustration. The lakes of central Washington County and of the southwestern part of Jackson County probably have a similar origin. The basin of Lake Ocheesee in the southeastern part of Jackson County rests upon the Chattahoochee Limestone, the Vicksburg being beneath this formation.

In Gadsden County between the Apalachicola and Ocklocknee Rivers the Vicksburg and the succeeding Chattahoochee limestones are buried to such a depth beneath later clayey and sandy formations that they do not appreciably affect the surface topography. It should be added, however, that the surface elevation in Gadsden County is high, the plateau being approximately 300 feet above sea. In the three counties lying next east of Gadsden, Leon, Jefferson, and Madison, while the Vicksburg limestone is nowhere exposed, yet the Chattahoochee limestone lying above it is occasionally exposed and the surface topography shows in the formation of large basins through solution and in the occasional formation of sinks, the effects of the underlying soluble limestones. The Suwannee River cuts through all of the later formations and exposes in its channel and valley the upper Oligocene limestones, but does not reach, so far as definitely determined, the Vicksburg. The northeastern part of Suwannee County and the adjacent part of Columbia County resemble Leon, Jefferson, and Madison Counties in that soluble limestones. while only occasionally actually exposed, lie sufficiently near the surface to affect the topography, resulting in the formation by solution of lake basins and sink holes. Over the northern part of Columbia and Baker Counties and thence east to the Atlantic coast the Oligocene limestones are buried to such a depth as not to affect the topography. At Jacksonville the Vicksburg is buried to the depth of 500 to 525 feet beneath later formations.

In peninsular Florida is found another extensive area, the topography and soils of which are influenced either by the Vicksburg Limestone itself or by this formation in connection with the overlying upper Oligocene limestones. The Vicksburg is exposed at many localities in southern Columbia, Alachua, Levy, Marion, Citrus, Sumter and Hernando Counties, and occasional exposures are recorded in Pasco County and in the northern part of Pinellas County.* To the south and east of this area the Vicksburg dips beneath later formations. The formation, however, affects the surface topography and the soils over a large area bordering its actual surface exposure. All the large section of country known as the lake region, owes its characteristic topography, in the writer's interpretation, to the influence of the underlying Vicksburg and probably other Oligocene formations. Aside from parts of Suwannee and Columbia Counties, and the counties of west Florida already mentioned, the lake region topography is found extending from Lake Kingsley in Clay County south through eastern Alachua, Putnam, the western part of Volusia, the western part of Orange, and the central part of Lake Counties, and thence south through eastern Polk County into DeSoto County.

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*Florida Geological Survey, Second Annual Report, page 65, 1909.

The records showing the depth at which the Vicksburg Limestone underlies the lake region, are fewer than could be desired. At St. Augustine and at Orange Mills east of the lake region of Clay and Putnam Counties, the Vicksburg has been recognized at the depths of 225 and 130 feet respectively. At Sanford near the east border of the lake region in Orange County the Vicksburg lies at a depth of from 113 to 125 feet. At Orlando, which lies within the lake region of Orange County, this formation was identified from well samples at a depth of from 130 to 250 feet, the well having terminated in this formation at 250 feet.* As to the depth of the Vicksburg underlying the southward extent of the lake region into Polk and DeSoto Counties we have no record beyond a statement by Dall that at Bartow in Polk County, "it (the Ocala Limestone) is covered by about 6 feet of later strata."† No one seems to have verified this determination of the formation at Bartow. However, from the topography the writer is led to believe that the Vicksburg may be expected underlying the lake regions of Polk County at a depth not exceeding 100 or 200 feet.

UPPER OLIGOCENE.

The Upper Oligocene is represented by the Apalachicola group of formations. This group includes the Chattahoochee, Tampa, Hawthorne, and Alum Bluff formations. The first three of these may be partly contemporaneous in time. The formations of the Upper Oligocene are variable in character and include limestones, shell marls, clays, fullers earth, and sands. They exert a much less characteristic effect upon the topography than does the Vicksburg formation. In some of the formations, moreover the fossils are few and poorly preserved. Thus the identification of the formation from well samples become difficult or impossible, and the thickness and extent of the different formations is not easily determined.

CHATTAHOOCHEE FORMATION.

The type exposure of the Chattahoochee formation is found in the vicinity of Chattahoochee in Gadsden County. The formation although variable is prevailingly an impure clayey limestone. As a rule strata of an impure limestone alternate with softer and more clayey layers, the latter being scarcely other than calcareous clays. Upon exposure this stratum weathers in a characteristic manner, breaking into octagonal blocks varying from two to six inches in size. Further weathering is by exfoliation and crumbling. The final product of weathering is a green sticky clay, the calcareous material having been largely removed. Numerous excellent exposures of the Chattahoochee formation occur along the Apalachicola River from the State line to Rock Bluff. The formation dips to the south and at Rock Bluff passes beneath later formations. Some good exposures of the Chattahoochee formation are seen on the Chipola River, the rapids of the river near Altha, in Calhoun County, being formed by this limestone. West of the Chipola River the formation is not extensively exposed and the limestone phase of the formation is probably not well developed. However, Matson and Clapp* note the occurrence of this limestone at Knox Hill, in Walton County, and on the Choctawhatchee River, at Caryville, in Washington County. To the east of the type exposure the formation comes to the surface at several places along the Ocklocknee River. A limestone probably of this formation is seen just above the crossing of the Georgia, Florida, & Alabama Railway between Tallahassee and Havana, and near the crossing of the Seaboard Air Line Railway between Tallahassee and Quincy. A similar limestone is very generally seen in the sinks and lake basins of the northern half of Leon, Jefferson, and Madison Counties.

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*Letter from George C. Matson of Nov. 24, 1908. Based upon the identification of fossils from the Orlando City well by Dr. Ray Basler.

†Bulletin No. 84, U. S. Geol. Survey, p. 104, 1892.

Although the limestone disappears by dipping beneath the surface at Rock Bluff on the Apalachicola River, and not far below the Seaboard Air Line Railway crossing on the Ocklocknee River, yet from this latter point the line of surface exposure bends southeast and reaches to the coast in the vicinity of St. Marks. From St. Marks east to the Suwannee River a similar limestone is frequently exposed or lies near the surface. The channel of the Suwannee River, as previously stated, cuts through Upper Oligocene formations. The distribution of the Chattahoochee Limestone east of the Suwannee River has not been determined.

TAMPA FORMATION.

The Tampa formation is similar in character to the Chattahoochee, and consists of clayey limestones and clays. The type exposure of the Tampa Limestone is along Tampa Bay. The silex beds exposed along Tampa Bay represent one phase of this formation. The rapids of the Hillsboro River are caused by this limestone. The formation is found at places along this river for about fifteen miles inland.

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*Florida Geological Survey, Second Annual Report, p. 84, 1909.

HAWTHORNE FORMATION.

The Hawthorne formation is less distinctly delimited than either the Chattahoochee or the Tampa formations. The type locality of the formation is at Grove Park about three miles west of Hawthorne in Alachua County, where the rock was at one time quarried as a building stone. At this locality an effort was also made to grind and use certain beds of this formation as a fertilizer, as the rock contains at these quarries a small percentage of phosphoric acid. The formation includes clays, rocks, and limestones, the latter being more or less phosphatic.

ALUM BLUFF FORMATION.

The Alum Bluff formation consists chiefly of sands, shell marls, clays, and fullers earth. The type locality is at Alum Bluff on the Apalachicola River. The sands of this formation are often highly calcareous, grading into sandy limestones. The marls are often highly fossiliferous, and are found chiefly in West Florida. Among numerous localities at which marls of this formation are exposed, are: Alum Bluff, Bailey's farm on the Chipola River, Oak Grove on the east border of Santa Rosa County, and along the Shoal River, in Walton County. East of the type exposure the Alum Bluff formation is extensively developed. It underlies all of Gadsden County and is exposed frequently in the numerous streams and on the public roads. It is also found in Leon County along the Ocklocknee River, and in Manatee County, the fullers earth stratum being mined at Ellenton. The formation probably originally covered a considerable area in central peninsular Florida, remnants still being found in Marion and Alachua Counties.

MIOCENE.

JACKSONVILLE FORMATION.

The Miocene in Florida includes two formations, the Jacksonville formation and the Choctawhatchee marl. The type locality of the Jacksonville formation is at Jacksonville, the first description having been based on specimens taken from the excavations at the city water-works. The formation is probably extensively developed in eastern Florida. It is well exposed along Black Creek in Clay County, and has been noted as far south as Rock Springs in Orange County. To the north of Jacksonville its extent is undetermined. Certain exposures along the St. Marys River at Orange Bluff and at Rock Bluff may represent this formation, although the age of these exposures has not been definitely determined. Well drillings at Jacksonville and elsewhere show that a formation resembling the Jacksonville formation extends to a depth of several hundred feet in the St. Johns Valley and along the East Coast.

The Jacksonville formation is prevailingly of a gray or buff colored material made up of coarse sand grains, calcium carbonate, pebble phosphate, and some clay. The relative amount of these different ingredients varies from place to place. The material from the type locality at Jacksonville has a high proportion of calcium carbonate with which is included some sand and clay and relatively little phosphate pebble, forming a sandy impure limestone, in which occasional fossils are found preserved chiefly as casts. The exposures along Black Creek in Clay County are similar to the exposure at Rock Springs in Orange County, although the relative proportion of pebble phosphate is increased, that along Black Creek having at one time been worked for phosphate. The phosphate pebbles in this formation are amber colored or black, and are smooth and shiny. They vary in size from very small pebbles, scarcely larger than a pin-head, to pebbles the size of marbles. In the lower part of the formation, as shown by well borings, the sand predominates over the calcareous matter, the material becoming a very sandy, calcareous marl. Phosphate pebbles occur throughout the formation to the depth of several hundred feet.

CHOCTAWHATCHEE MARL.

The Choctawhatchee Marl consists of gray sandy shell marl in which the fossil shells are often excellently preserved. The marl was first described from Alum Bluff on the Apalachicola River, where it is well exposed, lying immediately above the Alum Bluff sands. It is also well exposed along the Choctawhatchee River in West Florida.

It is difficult to say to what extent either the Jacksonville formation or the Choctawhatchee marl has affected the soils. When lying near the surface the calcareous material, and to a large extent the phosphatic material also is dissolved, by the surface waters and removed. The resulting soil is sandy, and is possibly not always distinguished from sandy soils resulting from other formations.

PLIOCENE.

The Pliocene is represented by several more or less well marked formations as follows: The Caloosahatchee Marl, the Nashua Marl, the Alachua Clays, the Bone Valley formation and the Dunnellon formation. The first two of these are marine formations and contain many well preserved marine fossils which serve to determine definitely their age. The remaining three, the Alachua Clays, the Bone Valley and Dunnellon formations, are less definitely determined. The Alachua Clay is apparently of fresh water origin, having been deposited in and around the borders of the many lakes which existed in the central part of the State. It is therefore a disconnected formation and the different deposits were not necessarily contemporaneous. In fact these lake deposits are doubtless a phase of lake formation and refilling which began in the Pliocene or earlier, and has continued to the present. The Bone Valley formation includes the land pebble phosphate deposits. These have been commonly referred to the Pliocene. They consist of pebble phosphate imbedded in a phosphatic clay.

The Dunnellon formation was described in the preceding report.* The materials of the formation are miscellaneous in character, and include sands, clays, gravel and pebble, flint boulders, limestone inclusions, and phosphate rock. The phosphate is of vast importance to agriculture, and its presence in the Dunnellon and Bone Valley formations lends especial interest to these deposits. In regard to the hard rock phosphate of the Dunnellon formation, the writer expressed the view in the paper referred to that the phosphoric acid has been very gradually concentrated from various formations in which it existed in very small quantities. In support of this view is the notable fact that the hard rock phosphate boulders, some of which are of immense size, have unquestionably formed and are forming *in situ*. The plate and fragmental rock represents boulders formed during a preceding stage and subsequently broken, more or less transported, and finally deposited in their present position. In support of this view of the origin of the phosphates it is a notable fact that hard rock phosphates in Florida occur only in sections which have been subjected to prolonged disintegration and erosion.

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*A Preliminary Paper on the Florida Phosphate Deposits, by E. H. Sellards, Third Annual Report, Fla. Geol. Survey, 17-41, 1910.

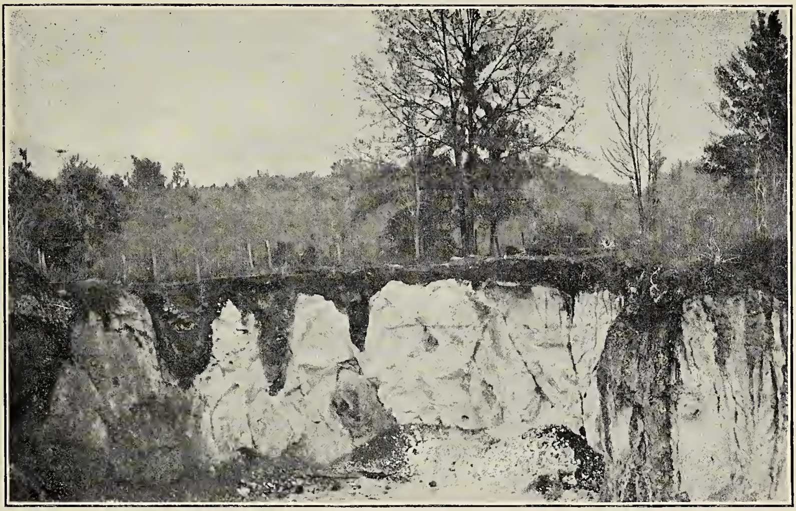

Fig. 1.—Cut on Georgia, Florida and Alabama Railway at Nicholson in Gadsden Count. At the top of the cut is seen ten feet of loose pale yellow residual sands. These are separated by a distinct line from the underlying reddish and partly indurated clayey sands.

See errata P. 176

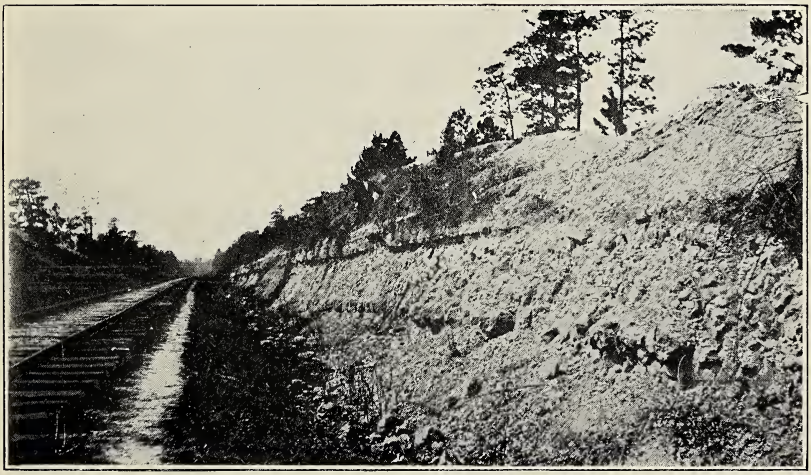

Fig. 2.—Exposure of the Chattahoochee formation in cut of the Atlantic Coast Line Railroad near River Junction.

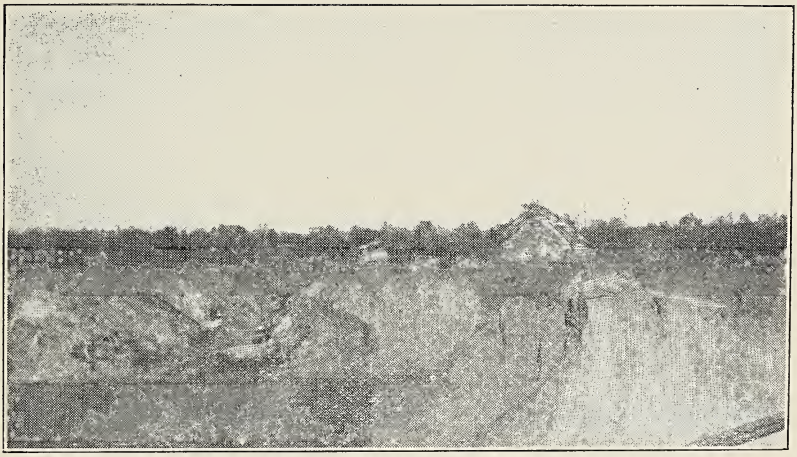

Fig. 1.—Exposure of the Dunnellon formation in a pit of Buttgenbach Phosphate Company near Holder, Citrus County.

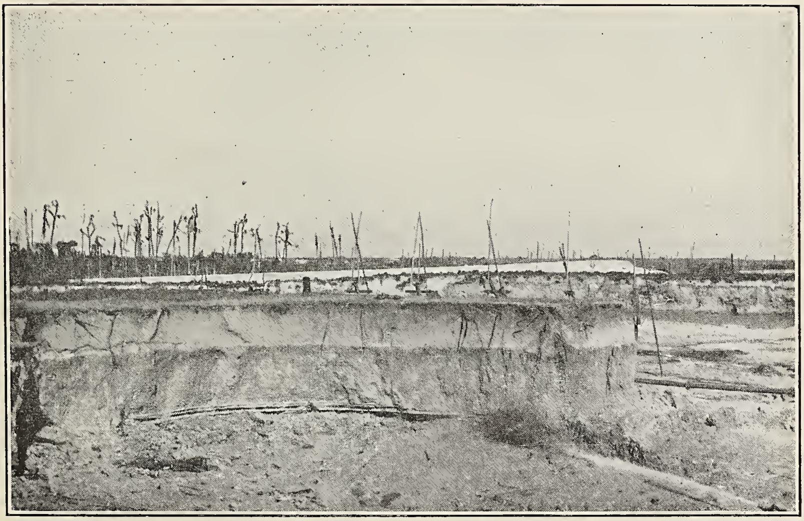

Fig. 2.—Exposure of the Bone Valley formation in pit number 5, Prairie Pebble Phosphate Company near Mulberry, Polk County.

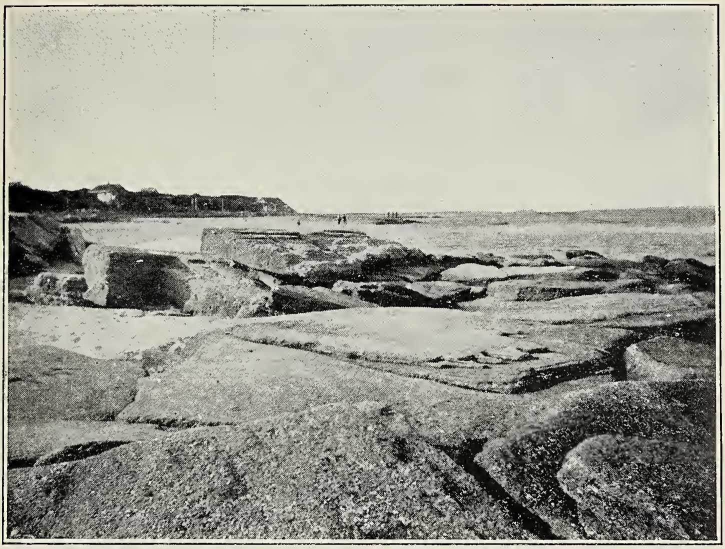

Fig. 1.—Exposure of the coquina rock of the Anastasia formation on Anastasia Island in St. Johns County.

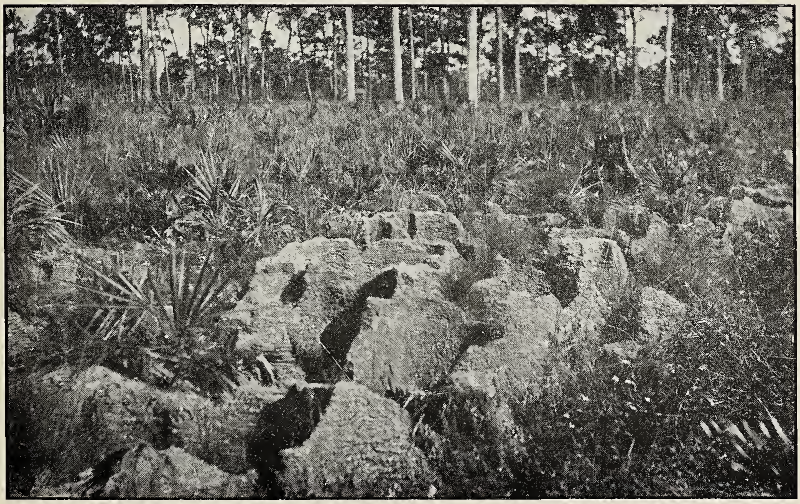

Fig. 2.—Exposure showing the top surface of the Miami Limestone. The extreme irregularity is due to solution.

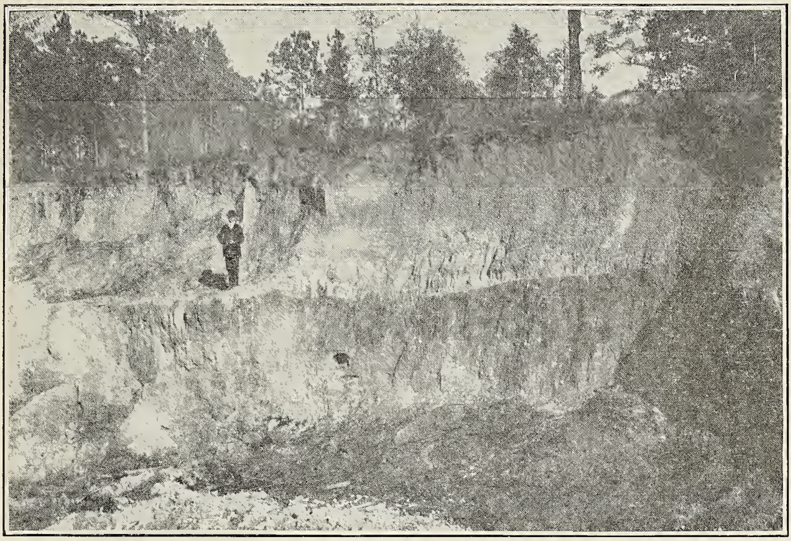

Fig. 1.—Cut on Georgia, Florida and Alabama Railway at Nicholson in Gadsden County. At the top of the cut is seen ten feet of loose pale yellow residual sands. These are separated by a distinct line from the underlying reddish and partly indurated clayey sands.

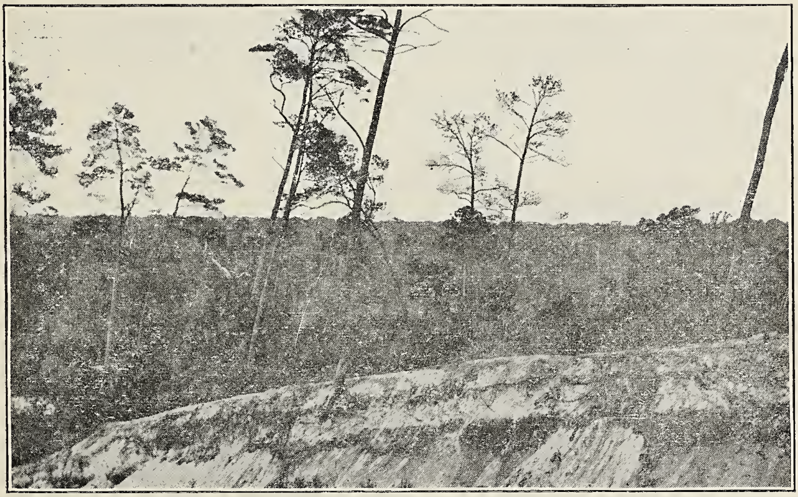

Fig. 2.—Cut in quiescent sand dune on the public road two miles west of Daytona. The top sands to a depth of four or five feet are light colored. The sands beneath are ochre yellow.

The hard rock phosphate of Columbia, Alachua, Marion, Levy, Pasco and Hernando Counties is found resting upon the Vicksburg Limestone, all formations later than the Vicksburg having disintegrated or nearly so, their residue forming the matrix and the phosphoric acid which they contained having become segregated to form the phosphate boulders. To the northeast of this phosphate field is found the uneroded plateau, beneath which, on this hypothesis no deposits of high grade rock phosphate are to be expected.

A limestone sub-structure is favorable to the chemical action which results in the formation of phosphate boulders. In the non-limestone section drainage is largely by surface streams. Under these conditions the phosphoric acid gathered into solution in small amounts from various sources throughout the soil is carried directly through streams to the ocean. In the limestone sections, on the contrary, the drainage is chiefly subterranean, and the rainfall after passing through the soil and underlying material and thus gathering up more or less phosphoric acid, passes into the limestone. Within the earth, and especially at and below the underground water level, the phosphoric acid is again thrown out of solution, thus forming the phosphate boulders. This hypothesis of the origin of the hard rock phosphate involves only those natural processes which are constantly in operation. It does not postulate a chain of islands the existence of which has not been demonstrated. Nor is it necessary to invoke the aid of bird rookeries, although these were doubtless a feature of the past as of the present, birds contributing then as now to the phosphoric acid supply of the soil. No one questions that the flint boulders which lie alongside the phosphate boulders are formed by chemical segregation of silica from various sources. An identical chemical process accounts for the phosphate boulders.

PLEISTOCENE.

Owing to the local character of the Pleistocene deposits much difficulty is experienced in describing the formations of this age. Local shell bearing deposits of Pleistocene age are found at many localities both along the coast and for some distance inland, particularly along the St. Johns River and in the Kissimmee River Valley. The limited extent of these deposits and their local character make it inadvisable to differentiate formations among the deposits. Some of the localities at which marine Pleistocene shell marls have been located are the following: on the Gulf coast; North Creek, a tributary to Little Sarasota Bay in Manatee County; Labelle, on the Caloosahatchee River; and on Six-Mile Creek near Tampa; and on the east coast at Ft. Lauderdale, Eau Gallie, Titusville and Mims, and at Kissimmee, in the central part of the peninsula, at a depth of 100 feet. Fresh water Pleistocene deposits containing often the remains of vertebrates, are found locally throughout the interior of the State.

In addition to the local Pleistocene deposits already mentioned several well defined marine formations of this age have been differentiated in southern Florida. These have been fully described in the Second Annual Report of the Survey by Mr. Samuel Sanford. The best known of these marine Pleistocene formations is the Miami Limestone. This formation is well exposed in the vicinity of Miami and generally along the eastern border of the Everglades from some miles north of Ft. Lauderdale to Homestead. It consists of a light colored oolitic limestone in which is included a small amount of sand. The limestone at Miami is quarried and used as a building stone. As is frequently the case with limestones, the rock when first uncovered is soft and can be easily worked, but hardens upon exposure, due to the deposition of calcium carbonate upon the evaporation of the water held in the interstices of the rock. A similar limestone at Key West is designated by Sanford as the Key West Limestone, although this may possibly be the southward extent of the Miami Limestone.

Another limestone is found along the keys from Key Largo to Knights Key. This is a coralline limestone and is of interest as being the only true coralline limestone in Florida. It is designated the Key Largo Limestone.

The term Anastasia formation is applied to the extensive deposit of coquina rock found along the East Coast. This formation is typically exposed on Anastasia Island opposite St. Augustine, and extends along the coast south from this point a distance of 150 miles or more. The coquina rock has been frequently described both in the reports of this Survey and elsewhere. It is made up of a mass of more or less water-worn shells, which in some localities are cemented to form a firm rock, but elsewhere may be slightly or not at all cemented. Some sand is frequently included in this formation and the cementing material is calcareous. Aside from the type exposure on Anastasia Island, the cut made by the Florida East Coast Railway on Tomora Creek near Ormond, and the exposure along the coast at Rockledge may be mentioned.

The Anastasia formation is probably contemporaneous or partly so with the Miami Limestone and the other Pleistocene limestones along the southern coast, all of these having been formed previous to the uplift that occurred during or at the close of Pleistocene time. It is probable that the coquina rock was formed near the close of this period of uplift as it is now found only a few feet above sea level.

UNCLASSIFIED GRITS, SANDS, AND SANDY CLAYS.

In addition to the formations described there is found in Florida an extensive deposit of sand, gravel and lenses of clay. This material forms the surface covering over a large extent of northern and central Florida as well as parts of the adjoining States. It is found entirely across the State from the Alabama line on the west to the Atlantic coast, and is found over the central part of the peninsular section as far south as DeSoto County. The classification of this superficial material has given rise to much difficulty owing chiefly to the fact that in Florida it is practically non-fossiliferous although a few plant remains have been found. It has been regarded in recent years by most writers as Pliocene in age, although as a matter of fact there is no satisfactory evidence that it may not be early Pleistocene. Moreover, it is quite possible that more than one formation or parts of formations are included under this head, the absence of fossils making it difficult to discriminate formation lines.

In the literature, this material will be found referred to most frequently as the Lafayette formation. The Lafayette formation was named by Dr. E. W. Hilgard, the type locality being at Oxford, in Lafayette County, Mississippi, where the formation is well exposed. This locality has recently been re-examined by Berry who, upon the evidence of the fossil plants finds the deposits to be of Eocene age.* From this evidence it would appear that the Florida material can not be correlated with the Lafayette as defined from the type locality, since in Florida the material everywhere rests upon deposits later than Eocene.

In his presidential address before the section of Geology of the American Association for the Advancement of Science in 1906, Professor E. A. Smith discussed the geology of the Gulf Coast. In regard to Florida, referring particularly to the western extension of the State from the Apalachicola River to the Alabama line, Smith at that time regarded the upper part of these deposits, the red sands and loams, as Lafayette, and the more or less stratified clays, sandy clays, and sands beneath, as representing the Grand Gulf formation. The Grand Gulf formation was also established by Hilgard, the type locality being Grand Gulf, Mississippi.

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*Journal of Geology, Vol. XIX, pp. 249-256, 1911.

In 1892 the term Altamaha Grit was applied by Dall to sands and grits found along the Altamaha and Ocmulga Rivers in Georgia. This formation had been previously briefly described but not named by Loughridge in the reports of the Tenth Census. Further descriptions of the Altamaha Grit have been given by Harper* and by Veatch,† both of whom refer to the extension of the formation into Florida. The map which accompanies Harper's paper represents this formation as reaching into the State along the east border of the Apalachicola River.

Whatever their geologic correlation, certain it is that these coarse sands, grits, and clays have a wide distribution and are an important factor in soil formation in the State. In soil studies, moreover, we are concerned only incidentally with the geologic correlation and age of formations, but more particularly with the lithologic character, the minerals present and their behavior under the weathering agencies. Whether representing one or parts of several formations, these deposits are closely similar in materials and react similarly under the processes of decay.

The most persistent and characteristic single feature of these deposits is the presence of water-worn, flattened, quartzite pebbles, usually light colored and sometimes almost clear, although as a rule they are clouded and more or less stained by iron oxide. Owing to their resistence to decay, these pebbles tend to accumulate on the surface as the formation decays, especially on slopes where the wash is sufficient to remove the smaller sand grains. They are also found quite generally in the stream beds.

The quartz sand grains which make up the largest part of the deposits are angular, and variable in size, although usually including more or less coarse sand. In regard to the texture of the sand, however, there is great variation from place to place, some localities having prevailingly coarse sand, while elsewhere the sand is prevailingly much finer. The color of the sand grains near the surface and within reach of the surface waters is often red, or ochre yellow, due to staining by iron oxide. Deeper within the formation, where not stained, the grains are usually perfectly clear and transparent. In form the grains are roughly angular.

In addition to the coarse sand grains and the flattened pebbles there is occasionally found local deposits of much coarser material. including water-worn flint pebbles up to one or two inches in length.

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*Annals; N. Y. Acad. Sci., Vol. XVII, pt. 1, 1906; Torreya, Vol. 6, 1906, p. 241.

†Science, Vol. XXVII, 1908, pp. 71-74.

One of the localities where this coarse material is found and where it has been extensively mined for road purposes is at Interlachen, in Putnam County. The section in the pit of the Interlachen Gravel Company is as follows:

Coarse sand and gravel, light colored or ochre yellow.....	3 ft.
Sand and gravel iron stained red, and feebly cemented....	5 ft.
Light colored coarse sand and gravel.....................	5 ft.

Another locality from which similar coarse material is obtained for road purposes is found near Grandin and Florahome in the same county. The pebbles are frequently one inch or more in length. Equally coarse pebbles are found along the line of the St. Andrews and Atlanta Railway a few miles south of Cottondale. It has been suggested that the coarse material in these deposits is found along the line of the principal rivers. It will be noted, however, that the three localities mentioned in Florida at which specially coarse material is found are all of them remote from any present river channel.

The clay intermixed with the coarse sand is in a finely divided condition and is probably the chief cementing material, giving the sand feeble coherence sufficient to form vertical walls. In addition to the clay it is probable that silica acts to some extent as a cement particularly in the few localities in which the sand becomes firmly cemented forming a hard rock. Iron oxide and probably iron carbonate act also as cements. The clay in the sand is frequently in the form of a ball clay or plastic kaolin, the ball clays mined at Edgar and near Leesburg coming apparently from these deposits. The clay strata and clay lenses include greenish and variegated clays.

Mica is intermixed with the sands and clays, and is removed from the ball clay in the process of mining. The mica is in the form of small flakes, a fraction of an inch in length.

The materials of these deposits are somewhat indefinitely stratified and frequently cross-bedded. Aside from the cross-bedding, distortion of the strata is frequently observed. This, however, is due in most if not in all cases to partial subsidence owing to solution in the limestones beneath, or to creep on the slopes. That the deposits were formed in shallow water and in the presence of conflicting currents is evident from the irregular stratification and the variable character of the material.

The admixture of finely divided clay kaolinitic in nature, with the coarse sands which characterizes these deposits is difficult to account for except upon the hypothesis that when deposited the formation consisted of coarse quartz and feldspathic sands. The quartz being resistant has remained but little changed, forming the coarse sand of the formation. The feldspar sands since their deposition have been subjected to decay, thus forming the kaolinitic clay of the formation.

SURFACE SANDS.

Lying above these grits and sandy clays is found, very generally, a mantle of loose sand. This sand covering gives character to a large percentage of the soils of the upland, interior section of the State, giving rise to the light sandy soils and loams. A number of geologists, among whom are McGee*, Eldridge† and Veatch‡, have regarded these sands as representing a distinct formation resting upon, and later than, the sandy clays. This hypothesis necessitates the assumption of a partial or complete resubmergence of the land subsequent to the deposition of the sandy clays, and hence if true is of much importance in its bearing on geological history and on soil formation. For this reason the hypothesis should be closely scrutinized before being accepted. The writer believes that the hypothesis is untenable and that the sands are in fact residual in origin, being derived by the ordinary processes of decay and disintegration of the underlying materials. All the observations cited by these writers so far as they relate to the upland section of the interior of the State admit of explanation on the view of the residual origin of the sand, while many conditions not mentioned by them give further support amounting, it would seem, to a demonstration of their residual origin.

McGee, it should be added, does not assume a complete resubmergence of western Florida. The peninsula of Florida, he assumes, was entirely resubmerged following the deposition of the red clays, which he regarded as Lafayette. The sands at the depot at Monticello in Madison County, he refers to the Pleistocene, implying that the depression was sufficient to submerge that point (now 202 feet above sea according to the levels of the Atlantic Coast Line Railway), but was not sufficient to submerge the somewhat higher land one mile farther north. The reference by Eldridge is specifically to the peninsula of Florida, which following McGee, he regards as having been resubmerged. Veatch in his paper relating to Georgia refers the sand overlying the Altamaha Grit to a separate formation of

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*McGee, W. J. The Lafayette Formation. U. S. Geol. Survey, 12th Ann. Rpt., pt. 1, 1891.

†Eldridge, George H. A Preliminary Sketch of the Phosphates of Florida. Am. Inst. Min., Eng. Trans. Vol. XXI, 1893.

‡Veatch, Otto. Altamaha Formation of the Coastal Plain of Georgia. Science (n. s.) Vol. XXVII, p. 71-74, 1908.

Pleistocene age. Mr. George C. Matson, at the time of the publication of his paper on the stratigraphy of Florida, regarded these gray sands throughout the State as representing a distinct formation of Pleistocene age.* The yellow sands he rightly surmised were residual in origin. In a subsequent page I shall endeavor to show that the difference in color between the gray and the yellow sand is due in most cases purely to the different drainage and other conditions under which they have accumulated. The loamy character of the yellow sands is due to the presence of a larger percentage of clay than is found in the gray sands.

One of the arguments advanced for regarding the gray sand as a formation distinct from the underlying clayey sands is the seeming unconformity which separates them. This distinct and clearly marked line is observed in practically all exposures. Ordinarily it approximately follows the contour of the hill or approaches the surface at the sides of the hill. Usually it is a fairly even line of division between the loose top sands and the more or less cemented clayey sands. Very frequently, however, the line is wavy or shows relatively abrupt trenches or small gullies. Unquestionably all these features closely simulate a true unconformity. But the fact must not be overlooked that in the processes of decay of superficial deposits, the line showing varying depth of decay is not infrequently an abrupt line and may show many of the irregularities of an unconformity. The true explanation of the well defined line marking the boundary between the loose sand and the clayey sand is as follows: The rainfall in passing through the top sands carries the finely divided clay which it holds to a lower level. This process results in an increased amount or concentration of clay in the lower strata. The percolating waters upon reaching this stratum are checked and move laterally to a point of exit. In its lateral movement water naturally tends to fall into water courses as it would do if flowing on the surface. In the process of time the water courses thus followed are widened and lowered, forming the irregularities observed in the exposure. The character of the clayey sands in question is such as to make the development of such lines of pseudo-unconformity particularly well marked.

Another argument advanced is the considerable depth to which the sands sometimes extend. The depth, however, is determined by the conditions of drainage, and by the soil water table which itself is determined by the drainage conditions. The deepest sand is found where the drainage is good, either by lateral seepage or by subdrainage. Subdrainage is best developed in those areas where the underlying material is a porous limestone, allowing the water after working its way through the clayey sand, to escape into the limestone beneath. Under these conditions, sand may accumulate to any depth, depending upon the thickness of the original clayey sands and their permeability to water. Some of the deepest of these sands are found overlying limestones. In such locations, the clay constituent may largely disappear from the material leaving loamy sands.

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*Fla. Geol. Survey, Second Annual Report, pp. 152-153, 1909.

In considering the origin of the loose sands, the peculiarities of the parent formation, the clayey sands, must be borne in mind. A first effect of decay is the loss and obliteration of stratification lines, giving the material the massive appearance observed in all shallow exposures. Usually two or three well marked stages of decay may be recognized. The stratum of least decay usually seen at the base of shallow exposures, is mottled and blotched in appearance owing to the irregular depth to which decay has reached. The blotched areas follow the lines through which the surface waters have gained entrance, and as seen in cross sections, often show in vertical streaks or in patches. The patches and streaks are colored more intense red than the surrounding sands, the development of the red color due to the oxidation of iron minerals being one of the early effects of decay. The thickness of this mottled stratum is variable, ten to twelve feet being often seen. The degree of mottling that is developed in an exposure depends largely upon the character of the material at that locality. A relatively high amount of clay in the sand favors mottling since the water permeates clay with difficulty, while nearly pure sands will scarcely become mottled at all owing to the fact that the water permeates them uniformly or nearly so. The line of demarcation between the mottled clays and the material next above is often a well marked line and has much the appearance of a break in the formation.

The stratum next above the mottled clay is usually a brick red loam. This is uniform in color as it has been thoroughly permeated by the surface waters and the iron minerals thoroughly oxidized. The clay minerals are well decomposed and the stratum has a loamy character although it still retains sufficient firmness to form vertical exposures. The amount of clay in this stratum may be considerable as it may have received more clay brought down by the percolating waters from above than it has as yet lost to the underlying stratum. This is the material that has often been regarded as typical Lafayette.

Next above the red loams are the loose surface sands already referred to. From these sands the clay has been largely removed by the surface water. These sands are usually ochre yellow in color, the iron having become hydrated, while those most affected by surface waters may have largely lost their stain, becoming light gray in color. The clay which originally acted as a cementing material has also been largely removed by the percolating waters, having either been carried to a lower depth or washed away entirely. Other cementing substances, if originally present, have been removed in solution, the resulting sands being loose and friable. The line of demarcation between this loose sand and the underlying loam as already explained is often an irregular line and practically always a well marked line.

The gray and yellow loose sands have been referred to above. It may be noted that invariably in localities where the drainage is sufficient to remove all or nearly all the organic matter, the top sands are gray or light colored, but that at a depth of from a few inches to a few feet the gray sands give place to ochre yellow sands, and various writers have sought to distinguish between the gray surface and the ochre yellow sands beneath. That no such distinction exists has been well pointed out by Mr. Samuel Sanford in the Second Annual Report of this Survey, 1909. The difference in color is due to different chemical action. Near the surface where the sands become thoroughly drained and aerated they bleach light or gray; deeper within the earth where the sands remain more or less moist the sands retain the ochre yellow color. Even originally light colored sands, will develop the yellow color when acted upon by surface waters carrying more or less organic acids in solution. That this is the case may be seen by examining a cross section of any one of the quiescent sand dunes covered with more or less vegetation. In the dunes along the coast the surface sands to a depth of one to three feet are light gray, but below the gray sands and separated from them by a well marked line, the sands become ochre yellow, thus showing the effects of staining of the sands by surface waters. When originally accumulated the dune sands were doubtless light colored and uniform throughout.

AGE OF THE GRITS, SANDS AND SANDY CLAYS.

Aside from their relation to soil formation the clayey sand deposits present some interesting geological problems. The fact that the material is coarse, indicates that it was moved to its present location by strong currents; the cross bedding and irregularity of the material indicates conflicting currents such as occur in shallow water or in deltas formed at the mouth of streams, or in the fan-like deltas formed by streams on land. The character of the material, including quartzitic fragments, quartz sand, mica, and probably originally feldspar, indicates the original source as the granitic rocks of the Appalachian Mountains, although possibly several times reworked in the course of their removal to the present location.

The age of the deposits is difficult to establish owing to the absence of fossils. On the Apalachicola River these deposits are found overlying both the Oligocene and the Miocene, thus fixing their age as later than Miocene.

On the other hand, the considerable amount of erosion and disintegration that has occurred since the material was accumulated implies a lapse of time that reaches back well into the Pleistocene if not into the Pliocene age. The disintegration that the deposits have undergone includes the formation of the surface accumulation of the loose residual sand representing complete decay; the formation of the red loams representing an advanced stage of decay; the blotched sandy clays representing partial decay, and the formation of the kaolin or ball clay, representing incipient decay affecting the least stable of the minerals. The length of time required for this amount of disintegration is difficult to estimate. Merrill states,* on the authority of Lindgren, that Pliocene andesites in the Sierra Nevadas in California are in places decomposed to a depth of 20 feet, and adds further, that the region is one of heavy annual precipitation, the rainfall being limited almost wholly to the winter season. The climate in Florida is warm and moist, and the rainfall heavy, amounting to about 53 inches annually, more than one-half of which falls during the three summer months.

The erosion that has taken place since these deposits were formed is extensive and affords a more satisfactory standard of measurement. This erosion is evidenced in the development of stream channels by surface erosion and the formation of valleys and lake basins by underground solution. In many of the limestone sections these deposits have become completely disintegrated, remaining merely as a residue intermixed with other materials. This condition is seen over large areas of peninsular Florida, including the limestone and the hard rock phosphate producing part of the peninsula. The lake basins of the lake region are believed, as shown in a previous paper, to result from underground solution. The sink holes in the lime sink regions are further evidence of underground solution. The extensive shallow lake basins of Leon, Jefferson, Columbia, Alachua, Hernando Counties, and elsewhere, are the evidence of advanced stages in the degradation of the land surface by underground solution which has occurred apparently since the deposition of these deposits and has involved their removal largely from the areas in question. In the non-limestone sections of the State the erosion is chiefly by surface wash and is measured by the development of streams and stream valleys. The valley of the Apalachicola River has apparently been widened and deepened and shifted to the east since the deposition of this material. This is indicated by the bluffs along the east border of the river capped by this formation and now standing 160 to 200 feet above the river valley. In the non-limestone sections, lateral streams have developed giving more or less perfect dendritic drainage. This extensive development and branching of small streams cutting through these deposits is seen in the northern part of Escambia, Santa Rosa, Gadsden and Liberty Counties. In most of the other counties the free development of surface streams has been more or less interfered with by underground solution.

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*Rocks, Rock-Weathering and Soils, p. 262.

The amount of erosion and disintegration to which the formation has been subjected is such as to give weight to the view that the material accumulated during either Pliocene or early Pleistocene. In considering the material, however, we must not lose sight of the fact that it has not been proven that this material covering an extensive area, necessarily all belongs to a single formation of the same age, since similar processes may have given rise to similar materials at various times and places.

TOPOGRAPHY.

Notwithstanding that Florida, the second largest State east of the Mississippi River, is extensive in area, no point within the State is distant from the coast more than 75 miles, and no elevations are found exceeding 300 or 310 feet above sea level. Originally, doubtless, the topography was comparatively simple, the rise in elevation being, with minor exceptions, gradual from the coast inland. However, as the result of differential erosion and other factors, well marked topographic types have developed, and at the present time the topography is varied.

The topographic development has been determined largely by the geologic structure, and the key to the topography of the State is obtained by observing the distribution of the limestone and the non-limestone formations. The importance of limestone formations upon the topography is due to the fact that the limestone is more soluble and more readily eroded than most other formations, and those sections of the State that are underlaid at no considerable depth by limestones have been more radically affected by erosion than the non-limestone sections, and have been affected in a different manner. The limestones erode chiefly by underground solution, as a result of which sinks, valleys and basins form, giving rise to a characteristic topography.

Although limestone formations underlie the State throughout, it is only in limited sections of the State that it is sufficiently near the surface to affect the topography. The limestones that exert the chief influence on topography in Florida are those of the Oligocene period, which are the thickest, purest and most extensive limestones found in the State. The Pleistocene limestones cover considerable areas along the Atlantic and Gulf Coasts in the southeastern part of Florida. Marls and other formations containing more or less calcareous material, are found in many parts of the State and in many instances affect the soil and the vegetation.

TOPOGRAPHY CONTROLLED BY OLIGOCENE LIMESTONES.

That part of the State in which the topography is controlled by the Oligocene limestones is indicated on the accompanying map. Two areas are shown, which are disconnected by the Apalachicola embayment. The smaller area in west Florida includes Jackson and Holmes Counties and parts of Washington and Walton Counties. The much larger area in central Florida extends from the Ocklocknee River on the west border of Leon County in a southeasterly direction to Pasco County. The area extends inland from the Gulf from 50 to 75 miles.

Although controlled by the underlying limestones the topography over the large areas outlined above is by no means uniform. Differences in elevation above sea level, in drainage conditions, and in the amount of erosion to which the land has been subjected give rise to a variety of topographic types and afford a basis of subdivision of the areas.

THE GULF HAMMOCK BELT.

Immediately adjacent to the coast and for a few miles inland the limestone lies at or very close to the surface. Few lakes exist, as the rainfall passes readily into the limestone. The underground water level is near the surface, and numerous large springs of limestone water emerge from the rock and flow to the ocean. This coastal strip contains numerous extensive calcareous hammocks and is known as the Gulf Hammock section of Florida.* If formations later than the Oligocene limestones were present over the Gulf Hammock area they have, with the exception of a slight residue of sand, disappeared. The Gulf Hammock section west of the Suwannee River is underlaid by Upper Oligocene limestones, while east of the Suwannee River the underlying formation is chiefly the Lower Oligocene limestone. Isolated areas of essentially similar country are found in the vicinity of Ocala in Marion County, and near Sumterville in Sumter County.

THE HARD ROCK PHOSPHATE BELT.

Inland from the Gulf Hammock area in peninsular Florida and to a lesser extent in that part of Florida west of the Suwannee River, is found a strip of country over which formations of later age than the Oligocene were clearly present in former times, although there now remains of these scarcely more than the mixed and complex residue. The formations that have gone to decay over this area include deposits of Pliocene age as shown by the fossils, and probably also marine formations of Miocene age. It is probable also that the Upper Oligocene formations were formerly present, although in this area in peninsular Florida these formations have disintegrated. The strip of country of this type extends in well marked development from the southern part of Suwannee and Columbia Counties roughly paralleling the Gulf Coast to Hernando and Pasco Counties. This area includes the hard rock phosphate deposits, these deposits having accumulated by the processes elsewhere explained during the period of erosion through which this section has passed. Few lakes or streams are found in the hard rock phosphate belt, as the rainfall enters through the loose surface material and passes directly into the underlying limestone. The underground water level, lies, as a rule at a greater depth beneath the surface than in the Gulf Hammock country. Numerous sinks form, giving evidence of the continued active erosion by underground solution. The surface contour is rolling, there being no regularity of hills or valleys. West of the Suwannee River workable phosphate beds have not yet been developed. Some phosphate, however, occurs in this section and larger deposits may yet be found.

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*E. A. Smith, U. S. 10th Census, Report on Cotton Production, Pt. 2, 1884.

MIDDLE FLORIDA HAMMOCK BELT.

Inland from the hard rock phosphate belt is found areas less affected by erosion in which more or less of the formations that originally overlaid the limestone may be identified in position. To this type of country Harper has applied the term Middle Florida Hammock belt.* In this belt of country the surface is rolling or somewhat hilly, and occasional flat bottomed lakes occur which occupy solution basins. The soils on the slopes are prevailingly red with red clay sub-soil. Surface streams occur, although most of these terminate either in lakes or in sink-holes through which they gain entrance to the underlying limestones, forming the disappearing streams characteristic of this type of country. In peninsular Florida two areas of Middle Florida Hammock lands may be designated. One of these includes a narrow belt extending in a northwest to southeast direction through Columbia and Alachua Counties into Marion County. A small part of Suwannee County east of Houston along the Seaboard Air Line Railroad is also included. This belt occupies the border land between the limestone and the non-limestone country of this part of the State. The second well-marked area is that which extends north and south through Citrus, Hernando and Pasco Counties, and is surrounded on all sides by more intensely eroded limestone country. West of the Suwannee River there is a large area of this type of country, including the northern part of Leon, Jefferson, and Madison Counties. The temporary lakes of Leon, Jackson, Jefferson, Madison, Alachua, Columbia, and Hernando Counties described in the preceding report,† all lie within this belt and are characteristic features of the topography. The red clay lands of Leon, Jackson, Jefferson, Madison, Alachua, Columbia, and Hernando and parts of other counties, arise from this stage of topographic development.

THE LAKE REGION.

The lake region of Florida as a physiographic type has long been known and often referred to in the literature of Florida. This type of topography includes a large area, extending from Clay County on the north to near the middle of DeSoto County on the south, its greatest width being found in Lake and Orange Counties. It is cut into by the St. Johns, Ocklawaha and Withlacoochee Rivers. Lakes, as implied by the name, are extremely numerous in this section of country. Surface streams are few, the rainfall passing into the soils.

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*Third Annual Report Fla. Geol. Survey, 1909.

†Some Florida Lakes and Lake Basins, by E. H. Sellards, 3rd Annual Report, Fla. Geol. Survey, pp. 43-76, 1910.

The lake region represents in the writer's interpretation an early stage in the degradation of the surface level by underground solution. The many basins now occupied by lakes have been formed by subsidence due to solution. Following the formation of the basins the surrounding uplands are gradually lowered, the tendency being to fill up the basins and to reduce the land surface once more to a common, although lower level. An examination of the accompanying map on which the lake region is separately indicated shows that this region represents the further southeastward extension of the limestone country of the peninsula.

The four topographic types described in the limestone country of the central part of the State are as follows: (1) The lake region, which represents an early stage of erosion in which deep circular lakes are surrounded by hills of approximately the height of the original table land. (2) The hammock belt, which includes flat-bottomed lakes, or lake basins now occupied by prairie lands, surrounded by hills more or less lowered by erosion from the original level of the plateau. (3) The hard rock phosphate belt in which the formations that formerly overlay the Oligocene limestones have disintegrated, leaving only the mixed and complex residue. The phosphoric acid originally contained in the overlying formations has been taken into solution by percolating waters and reaccumulated at a lower level, forming the hard rock phosphate. (4) The fourth type is that designated as the Gulf Hammock land. In this section formations later than the limestones, if formerly present, have disintegrated and have been entirely removed with the exception of an insignificant residue of loose sand.

While the types described above are well-marked, there are intermediate stages and other variations arising from local conditions. The intermediate stages between the hammock belt of rolling red clay lands with large but shallow lakes, and the hard rock phosphate belt with rolling sandy lands and no lakes, include rolling lands with more or less clay and with frequent or occasional sink hole lakes.

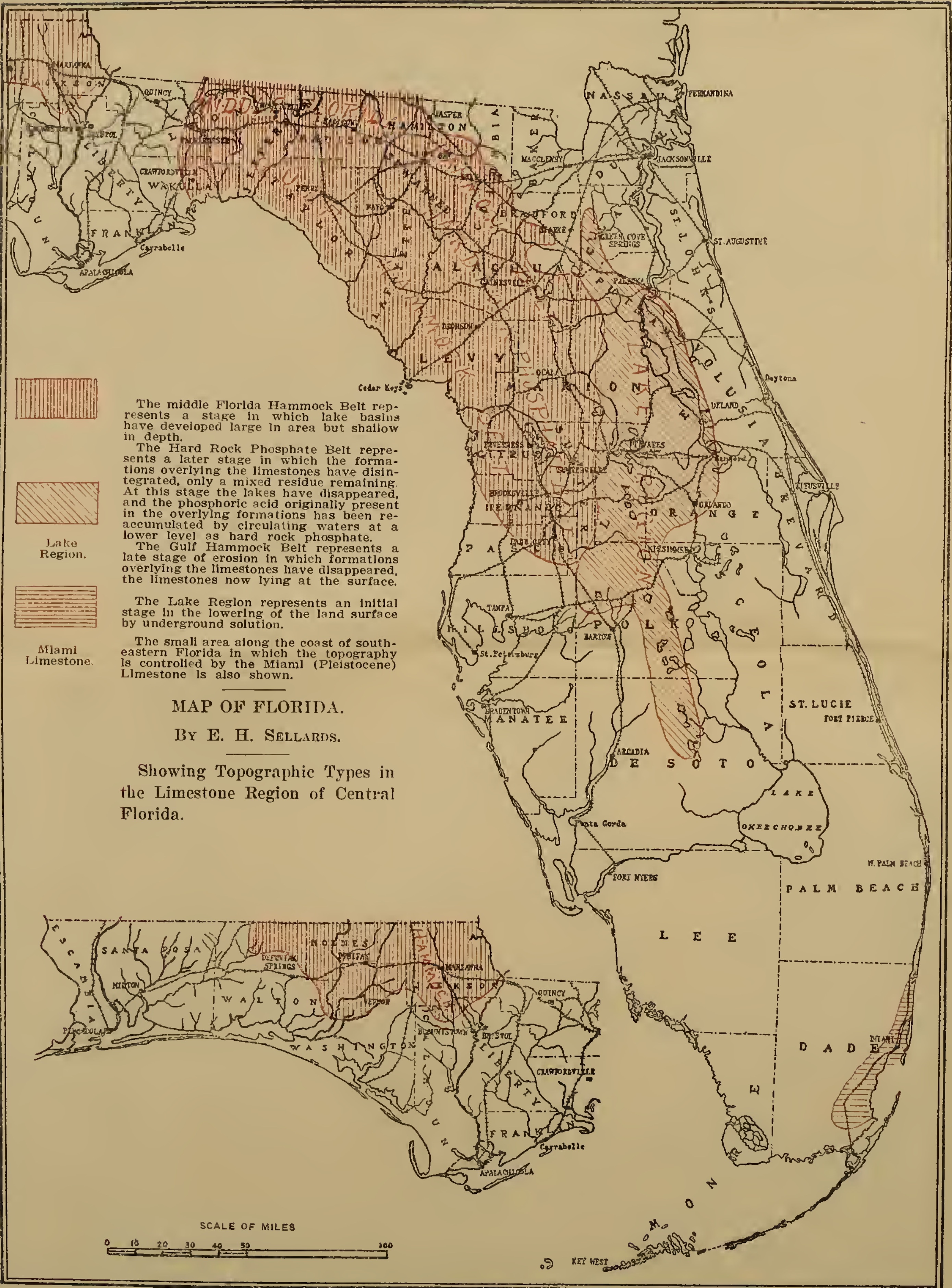
TOPOGRAPHY CONTROLLED BY PLEISTOCENE LIMESTONES.

The Pleistocene limestones of southern Florida for the most part lie so close to sea level as to exert no appreciable effect on the topography. The Miami Limestone forms a partial exception. This formation over a small area in Dade County lies at an elevation of from 9 to 15 feet above sea. The top surface of this limestone is exceedingly rough, owing to differential solution. A small amount of loose sand lies on the surface which tends to fill up the irregularities in the limestone. The limestone is cavernous, and occasional sinks or openings to the underground cavities occur. The area affected by the Miami Limestone extends from near the north line in Dade County to some miles below Homestead, being broadest at Homestead. Cuban pine is the prevailing forest tree over this area. Saw palmetto is the chief undergrowth.

The Keys between Miami and Key West, the foundation of which is limestone, rise but a few feet above sea level. The coquina limestone which lies along the Atlantic Coast, together with local marls, gives rise to the long strip of calcareous hammock land that occurs along the Atlantic Coast south of St. Augustine.

NON-LIMESTONE SECTION.

In the non-limestone sections of the State erosion has been chiefly mechanical by normal stream action, and the physiographic types are determined largely by the drainage conditions. Near some of the larger rivers surface drainage by lateral streams has been fully developed. This is true of the Apalachicola River, especially along its east side, where the rise in elevation to the plateau level is rapid, a narrow strip along the western border of Gadsden County being thoroughly drained by the numerous small tributaries to this river. The central part of this county is also well drained by the tributaries to Little River. The northern parts of Escambia and Santa Rosa Counties include areas well drained by streams tributary to the Perdido, Escambia and Black Rivers. On the other hand there are areas that are swampy owing to the fact that surface streams have not yet developed sufficiently to afford drainage. The large area of southern Florida known as the Everglades is of this type. The Everglades, as previously stated, probably date from the close of the Pleistocene period, and since that time numerous small streams have been cutting their way back from the coast. Among these are New River, Hillsboro River, Miami River, and some smaller creeks flowing into the Atlantic, and North River, Harney River, Lostmans River, and many smaller creeks, flowing into the Gulf from the southern end of the Everglades; and the Caloosahatchee River, which flows west from Lake Okeechobee. Ultimately by the action of these streams the 'Glades would be drained. The



The middle Florida Hammock Belt represents a stage in which lake basins have developed large in area but shallow in depth.

The Hard Rock Phosphate Belt represents a later stage in which the formations overlying the limestones have disintegrated, only a mixed residue remaining. At this stage the lakes have disappeared, and the phosphoric acid originally present in the overlying formations has been reaccumulated by circulating waters at a lower level as hard rock phosphate.

The Gulf Hammock Belt represents a late stage of erosion in which formations overlying the limestones have disappeared, the limestones now lying at the surface.

The Lake Region represents an initial stage in the lowering of the land surface by underground solution.

The small area along the coast of southeastern Florida in which the topography is controlled by the Miami (Pleistocene) Limestone is also shown.

MAP OF FLORIDA.

By E. H. Sellards.

Showing Topographic Types in the Limestone Region of Central Florida.

drainage operations now being carried on by the State make use of the channels already cut out to the 'Glades by the largest of these streams, continuing and deepening them into the 'Glades.

Another large area of land imperfectly drained by surface streams is found in the northwestern part of St. Lucie and the southern part of Brevard Counties. Extensive drainage operations by private enterprise are being carried on in this section. Five townships lying near the head waters of the St. Johns River in this section are being drained by the Felsmere Farms Company. In these operations the Sebastian River, which flows into the Atlantic, is utilized, the channel being deepened and continued to the undrained land.

The Okefinokee swamp of Southern Georgia and the smaller swamps which constitute its southward extension into Florida, includes a large area lying between the head waters of the Suwannee and the St. Marys Rivers to which surface drainage by streams has not yet penetrated. Many smaller areas occur throughout the State that have not yet been drained by surface streams, the topography being immature.

It is a striking fact that erosion is more rapid in the limestone than in the non-limestone sections, and that the limestone country is encroaching on the non-limestone country. Evidence of this fact is found both in west Florida and in peninsular Florida. In Washington County the Vicksburg Limestone lies at or near the surface in the northern part of the county, but dips in passing to the south. In crossing this county from north to south it is observed that an escarpment of approximately 100 feet in height marks the line between the limestone and non-limestone country. The rise to the plateau is known locally as Sexton Hill. Orange Hill, Oak Hill and other hills are outliers from the plateau. Holmes valley represents the transition grounds from the limestone country to the plateau. The history of the development of the topography of this county is easily understood. The limestone country of the northern part of the county is slowly encroaching on the non-limestone country to the south. Similar conditions are found in Jackson County. The narrow belt of lake region topography which includes Round Lake and other lakes on the St. Andrews Bay and Atlanta Railway represents the transition line between the limestone and the non-limestone sections of this county.

In the northern part of peninsular Florida the limestones are near the surface over a considerable area bordering the Gulf, including parts of Suwannee, Columbia, Alachua, Marion, Sumter, Pasco, Hernando, Citrus and Levy Counties. Suwannee County lies chiefly within the limestone area. This county, which is bounded on the north, west and south by the Suwannee and Santa Fe Rivers, has undergone rapid erosion and the formations which overlaid the limestones have largely disintegrated, except a relatively small area farthest removed from the streams along the east line of the county, which is at present in a transition stage of degredation, as indicated by the numerous lake basins formed by solution.

The southern part of Columbia County reaches into the limestone formations, and in that part of the county bordering the Santa Fe River the formations lying above the Vicksburg Limestone have entirely disintegrated. Farther north in the central part of the county, is found red clay lands, solution lake basins, and disappearing streams, indicating a transition stage in which the formations above the limestones have partly disintegrated. The extreme northern part of the county reaches into an area the topography of which has not yet been affected by solution.

Alachua County presents much diversity in topography. Over most of the western part of the county adjoining the Suwannee and Santa Fe Rivers the Vicksburg Limestone lies near the surface. The hard rock phosphate belt crosses this part of the county and the land is well drained, as the rainfall passes almost immediately into the soils or disappears through the numerous sinks. The northeastern part of the county is much higher in elevation and forms a level plateau 175 to 200 feet above sea. The Middle Florida Hammock Belt crosses the central and includes most of the southeastern part of the county. Numerous large shallow lakes or "prairies" are found in this part of the county, of which Paynes Prairie, or Alachua Lake, is an example. These prairies represent local areas that have been carried by underground solution practically to the underground water level. During seasons of heavy rainfall they become lakes. During dry seasons the water runs off through sinks, leaving the lake basin dry, or nearly so.

The history of the development of the topography of Alachua County is not difficult to understand. The western part of the county has been subject to rapid and profound erosion chiefly by underground solution. The formations that originally lay above the Oligocene limestones have largely disappeared, having been disintegrated and carried away either in solution or by mechanical wash. The elevated land in the northeastern part of the county represents the as yet uneroded part of the original plateau. The first effects of the erosion by underground solution are evident in this plateau in the formation of occasional sinks of which the "Devil's Mill Hopper," a sink hole exceeding 100 feet in depth, is an example.

The southeastern part of this county, like the western part, has been affected by erosion although under somewhat different conditions. From this part of the county the drainage originally passed through Orange Creek to the St. Johns River. The first lowering of the surface level was therefore by mechanical wear. In the course of time, however, Orange Creek eroded its bed until it approached the limestone. Sink holes then formed through which the water enters the underlying limestone. Phosphate deposits are scarcely to be expected in this type of country as the disintegration of the formations above the limestone has not been complete.

The same principles have operated in determining the topography of the other counties of the limestone belt. The hard rock phosphate belt represents the area in which the formations lying above the Vicksburg Limestone have almost entirely disintegrated. The Lake Region and the belt of clay hammock lands including shallow flat-bottomed lakes and disappearing streams, are transition stages. The Alachua Clays of Pliocene age are lake deposits which very probably accumulated while the area in which they occur was passing through the topographic stage in which lakes existed. The hard rock phosphate deposits accumulated in their present form during the progress of erosion, the phosphoric acid, taken in solution by waters percolating through the surface formations, having reaccumulated at a lower level.

INFLUENCE OF DRAINAGE ON SOILS.

The soils are affected by the drainage conditions in various important ways, to only a few of which it will be possible to refer in this paper.

ORGANIC MATTER.

The organic matter content of virgin soil is controlled to a large extent by the drainage, together with the atmospheric and climatic conditions. Moisture, owing to the extent to which it retards oxidation, is a great preservative of organic matter. Muck, as has been elsewhere stated, accumulates only where the amount of water in or over the soil is sufficient to retard the decay of the vegetation. On the other hand, where the drainage is good and the soils exposed to the direct rays of the sun, the organic matter natural to the soil oxidizes and may disappear.

THE COLOR OF SOILS.

The color of soils, which is an important guide in soil classification, is dependent upon chemical reactions which are controlled to a large extent by the drainage conditions. The chief mineral stain in soils is iron in its varying forms. Those soils and sub-soils that are thoroughly saturated with water at all times are likely to be dark or drab in color. The dark color is due to the fact that the iron is in an un-oxidized or de-oxidized condition. When partly, although imperfectly drained, soils assume a mottled appearance, the mottling being due to the partial oxidation of the iron. The bright red soils are those in which the iron has been thoroughly oxidized and exists in the non-hydrated form, hematite. The ochre yellow soils are believed to be stained in most cases by the dehydrated iron oxide. Those soils which lie on the slopes and are well drained and are rapidly renewed by the addition of soil material from beneath are most frequently red in color. On the other hand, the ochre yellow soils are found in areas where both drainage and aeration are good, but where the conditions are such that there is little or no surface wash, and where consequently the renewal of the soil is slow. It is probably true that red soils when long exposed to the air and to moisture such as is afforded by capillary movement, change over to yellow soils, the change in color being due to the hydration of the iron oxide.

The dark color in soils is due in most instances to organic matter which accumulates, as explained in the preceding paragraph, under moist conditions.

THE WATER TABLE.

By the term water table is meant the level at which water stands in the soils. Above this level, while the soils may be and usually are moist, the moisture is that due to capillary movement of water and the soils are aerated. At and below this level the soil is saturated with water and the air is practically excluded. The physical and chemical conditions above and below the water line are consequently in marked contrast. Above the line the oxidizing processes prevail; below the line de-oxidizing processes prevail. The minerals above the water line tend to assume the form of oxides; while below the water line the minerals more frequently exist as sulphides or sulphates. Above the water line the movement of water following heavy rains is free and solution is active; below the water line the movement of water is sluggish and limited and decomposition instead of solution may occur. The importance of the water table to the character of the soil in the flatwoods region of Florida has been well expressed in the Soil Survey of Jefferson County by G. B. Jones and others of the Bureau of Soils as follows:* "A profile of the flatwoods region taken in any direction would be a slightly wavy or broadly undulating line; if the average level of the water table were represented by a nearly horizontal line the latter would cut the former at many places. The areas of drained and undrained land would not only be graphically shown, but the distinctive features of each soil would be suggested. The organic content is a very important as well as conspicuous element in each type. The amount and form in which it appears is directly dependent upon drainage.

"The Norfolk soils would be represented by the highest parts of the profile. They lie well above the plane of permanent saturation and the organic matter is in the form of humus. The swamp and marsh would coincide with the lowest portion of the cross section. They contain a large amount of vegetable remains, mostly in the form of muck mixed with fine sand. The intermediate level would represent the Portsmouth and Leon soils."

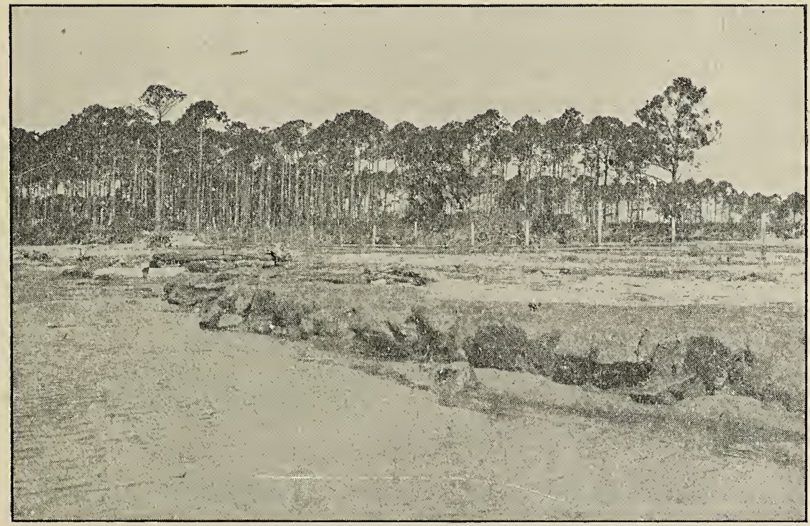


Fig. 1.—Exposure of hardpan on Apalachicola Bay. Palmetto flatwoods in the background. Photograph by R. M. Harper.

THE HARDPAN.

The hardpan of the palmetto flatwoods of the Coastal Plains affords a striking illustration of the relation of the soil conditions to the water line. The hardpan forms at the average level of the water table. It consists of a stratum stained dark or chocolate color by organic matter. During the dry seasons when the water table falls below its average level the hardpan is firmly cemented, presumably by the coating of organic matter. In this condition it can scarcely be penetrated by the soil auger, and interferes with the movement of water by capillarity. During the rainy season when the water table rises above the average level, the hardpan stratum becomes saturated with water and tends to disintegrate. Although many details of the formation of hardpan remain to be explained, it is evident that organic matter from the surface stratum is carried downward in some form by the water and is reaccumulated in the hardpan stratum.

TRANSLOCATION OF CLAY PARTICLES.

Another important feature of the drainage conditions is the translocation of clay particles. By this term is meant the removal of the finely divided clay particles from the soil near the surface and their reaccumulation at a lower level. This process is of special importance under the conditions which exist over large areas in the interior of Florida. The soils over large areas in central Florida are derived from a clayey sand rock. The clay in this formation which acts chiefly as the cementing material is in a very finely divided condition. Upon the disintegration of the formation, the clay particles are loosened, and are carried by the percolating waters to a lower level, and are there reaccumulated. Under conditions of good surface drainage and heavy rainfall this process long continued results in washing the sand free of clay to a considerable depth, and in the accumulation of an increased amount of clay in the stratum beneath. The dividing line between the sand washed free of clay and the stratum beneath in which the clay occurs in excess is often a well-defined line. The clay stratum accumulated in this way is some times referred to as hardpan, although it is different in character from the hardpan of the flatwoods.

SOILS.

Soil is the relatively thin covering of fragmental material that more or less completely mantles the surface of the earth and serves as an anchorage for and contributes to the growth of plants. The basis of this material is inorganic, and is derived from the decay and disintegration of pre-existing rocks. It consists of mineral particles of varying size and of various kinds. With this is included more or less organic matter resulting from the decay of vegetable or animal life. While the mineral matter usually predominates, some special soils, as those derived from muck and peat deposits, consist largely of organic matter.

The average soils consist chiefly of the clay minerals, and of siliceous sand and gravel. However many other minerals occur in soils, and almost any mineral which is relatively insoluble, and is also not readily decomposed may be expected as a soil ingredient. The soils are continuously forming by the disintegration of rocks, and after being formed are further affected and modified by the topographic, climatic, drainage and other conditions to which they are subjected. The readily soluble minerals are largely removed, and the unstable minerals are decomposed. Thus in the process of the decay of rocks and the formation of soils the sulphides in the rocks are changed to the more stable oxides. A soil formed from a limestone consists chiefly of the clayey or other impurities of the formation, the carbonates which make up the chief part of the limestone, having been removed in solution. From the granitic rocks there is removed in the process of decay the soluble constituents including the carbonates, and the other readily soluble minerals. The resulting soils consist of the relatively insoluble minerals which existed in the rock or which were formed during the process of decay, including the clay and sand. In addition to the removal of the ingredients by solution there is also more or less mechanical separation of materials by the sorting power of water. This is distinctly so in transported soils, and occurs to some extent in residual soils.

Chemically the soils are complex. Their productiveness depends among other things upon the mineral constituents present, the physical condition of the soil, and the chemical elements available to plant growth.

THE CHEMICAL ELEMENTS.

About eighty chemical elements have been recognized as present in the earth or in the atmosphere surrounding the earth. Of these some are very rare, occurring only in small amounts, while others are abundant. The element oxygen alone is estimated to make up 49.78%, or practically one-half of all known terrestrial matter, while oxygen and silicon together make three-fourths (75.86%). The nine most abundant elements, oxygen, silicon, aluminum, iron, calcium, magnesium, sodium, potassium, and hydrogen, make up 98.3%. The twenty most abundant elements make up 99.52%, the remaining sixty elements combined constituting only .48%. These estimates are made by F. W. Clarke, of the United States Geological Survey and are based on a calculation of the constituents of the air and the ocean, and of the crust of the earth to a depth of ten miles. The materials of the interior of the earth at a depth greater than ten miles are too imperfectly known to be included in the estimate.

The following is the list of the twenty most abundant elements including the estimate of the amount of each in the crust of the earth as given by Professor Clarke.*

Average composition of lithosphere, ocean, and atmosphere.

	Lithosphere (93 per cent.)	Ocean (7 per cent.)	Average, including Nitrogen.
Oxygen	47.07	85.79	49.78
Silicon	28.06	....	26.08
Aluminum	7.90	....	7.34
Iron	4.43	....	4.11
Calcium	3.44	.05	3.19
Magnesium	2.40	.14	2.24
Sodium	2.43	1.14	2.33
Potassium	2.45	.04	2.28
Hydrogen	.22	10.67	.95
Titanium	.40	....	.37
Carbon	.20	.002	.19
Chlorine	.07	2.07	.21
Bromine	......	.008	......
Phosphorus	.11	....	.11
Sulphur	.11	.09	.11
Barium	.09	....	.09
Manganese	.07	....	.07
Strontium	.03	....	.03
Nitrogen	......	....	.02
Flourine	.02	....	.02
All other elements	.50	....	.48
	100.00	100.00	100.00

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*The Data of Geochemistry, Bull. 330, U. S. Geol. Survey. p. 32, 1908.

CHEMICAL ELEMENTS ESSENTIAL TO PLANT GROWTH.

Of the eighty known elements only about ten are believed to be essential to the growth of plants. These are: Carbon, calcium, hydrogen, iron, magnesium, nitrogen, oxygen, phosphorus, potassium, and sulphur. Five other elements although probably not essential, are commonly present in plants. These are: Aluminum, chlorine, manganese, silicon, and sodium. Aluminum and silicon make up a part of all clay minerals, and hence are indirectly essential to plants, constituting a part of the soils in which plants find anchorage and grow. Flourine is sometimes recognizable in the ash from plants, and iodine seems to be normal to sea weeds and sometimes occurs in traces in land plants.

RELATIVE ABUNDANCE OF THE ESSENTIAL PLANT ELEMENTS.

The following table gives the amount of each of the ten essential elements in the earth's crust, the ocean, and the atmosphere. The five non-essential elements commonly present in plants are also included.

Table showing the amount of the essential plant elements in the earth's crust, the ocean, the atmosphere, and in the kernel of corn.

NAME.	In the Earth's Crust (per cent)	In the Ocean (per cent)	In the Air (per cent)	In the Corn Kernel (per cent)	NOTES.
Calcium	3.44	.05	......	.022	Derived by plants from the soil. (Nitrogen is derived chiefly although not entirely from the soil).
Iron	4.43	......	......	.008	
Magnesium	2.40	.14	......	.125	
Nitrogen	trace	......	75.50	1.760	
Phosphorus	.11	......	......	.300	
Potassium	2.46	.04	......	.340	
Sulphur	.11	.09	......	.004	
Hydrogen	.22	10.67	......	6.400	Derived by plants from sources other than the soil. From the water and the air.
Carbon	.20	......	.01	45.000	
Oxygen	47.07	85.79	23.00	46.000	
Aluminum	7.90	......	......	......	Commonly present in plant structure although regarded as non-essential.
Chlorine	.07	2.07	......	.013	
Manganese	.07	......	......	......	
Silicon	28.06	......	......	.014	
Sodium	2.43	1.14	......	.013	

The table is adapted from Professor C. G. Hopkins' text on "Soil Fertility and Permanent Agriculture," page 13. The estimate of the amount of each element present in the ocean and in the earth's crust is that made by Professor F. W. Clarke as given in the preceding table. The estimated composition of the air is that of Sir William Ramsey as quoted by Professor Hopkins. Professor Hopkins' estimate of the amount of each of these elements in a kernel of corn is added to give an idea of the amount of each element demanded in plant growth.

While this table indicates approximately the average amount of each of the essential plant elements in the crust of the earth, it does not show the amount of each present in soils. The average in soils may be above or below this general average, depending upon the constituents themselves and the conditions under which the soils have accumulated.

PLANT FOOD TAKEN FROM THE SOIL.

Of the ten elements essential to plant growth six are derived solely, and a seventh chiefly from the soil. The others are taken by the plant either from the atmosphere or from water. The elements taken entirely from the soil are calcium, iron, magnesium, phosphorus, potassium, and sulphur. Nitrogen is taken chiefly from the soil, although the legumes and some other plants are able to take a part of their nitrogen from the air. The three remaining essential elements, carbon, oxygen, and hydrogen, are taken directly from the air and the water, the carbon dioxide gas of the atmosphere and water absorbed through the roots being the sources of supply. As regards the amount of materials, the carbon, oxygen and hydrogen taken from the air and water make up approximately 95 per cent. of the bulk of plant structure by weight, the seven elements taken from the soil combined making up only about 5 per cent. Although required in such relatively small quantities these elements are none the less necessary, and if any one of the seven is lacking or deficient or not available, the productiveness of the soil is thereby reduced.

Calcium:—Calcium is an abundant element in the earth's crust, the estimated amount being 3.43 per cent. It is not found free or uncombined, but is a constituent of many minerals, the most common of which are the carbonates and sulphates, limestone and gypsum. The amount of calcium demanded by plants is, as will be seen from the table, exceedingly small as compared with the large amounts existing in the earth. Except in the cultivation of legumes, it is rarely the case that calcium needs to be added to soils as a plant food. It is, however, not infrequently needful as a soil treatment, being required particularly in muck or other sour soils to neutralize the acids, which if not neutralized will act as a deterrent to many plants. For this latter purpose this element in the form of a ground limestone, lime or air slaked lime, is coming to be extensively used, particularly on Florida soils. It should be noted that the soils may contain sufficient calcium to serve as plant food and yet the soil remain acid, the calcium not being in a form available to correct acidity. In addition to the calcium incorporated in the organic structure of the plant, considerable additional amounts are sometimes taken up and deposited in the coarser tissues of the plant. The purpose of the calcium so deposited is possibly to neutralize organic acids, that might otherwise be injurious to the plant.

Iron:—Iron occurs free in nature to some extent and is a constituent of many minerals. In its various forms it is slightly more abundant than calcium, the estimated amount in the earth's crust being 4.43 per cent. It is present in all soils and is the chief coloring constituent. The most common and best known iron minerals are the oxides, limonite, hematite and magnetite; the carbonate, siderite; and the sulphides, pyrite, marcasite. There are also many silicates of which iron is a constituent. The amount of iron required by plants is insignificant as compared to the relatively large amount occurring in soils.

Magnesium:—Magnesium, like calcium, is not found native, but as a mineral constituent is only a little less abundant than calcium, the estimated amount in the earth's crust being 2.40 per cent. The most common mineral is the double carbonate of calcium and magnesium, dolomite. It is also a constituent of many silicates. Plants require many times more magnesium as a plant food than calcium. The supply in the earth, however, is such that the supply of magnesium rarely becomes exhausted in soils.

Nitrogen:—Nitrogen in the free or uncombined condition is a gas, and as such makes up three-fourths (75.5%) of the atmosphere. It is a very inert element and rarely combines with other elements. It is a constituent of the nitrates and the ammonium minerals. The nitrates are the most important minerals, but being readily soluble in water they accumulate in quantities only under exceptional conditions. The sodium nitrates of Chili are the most extensive known deposits. Nitrogen exists in the soil as nitrates and as nitric acid. It is also a constituent of organic matter from which source it becomes available to plant growth through the action of bacteria. The legumes and a few other plants as previously mentioned, are able to get a part of their nitrogen directly from the air. All other plants derive nitrogen from the trace contained in the earth. Notwithstanding the scarcity of nitrogen in the soil the amount used by plants is considerable, the corn kernel containing as estimated by Professor Hopkins, 1.76%, or more than twice as much as all other elements derived from the soil combined. As a result of the small amount in the earth and the relatively large amount used by plants, nitrogen is one of the elements likely to become deficient in soils.

Phosphorus:—Phosphorus in small quantities is a constituent of nearly all igneous or primitive rocks. It occurs chiefly as salts of phosphoric acid, namely, the phosphates, the most important of which is calcium phosphate. It is also an essential ingredient in all plants and animals forming a part of the nucleus of all living cells. It forms also an important part of the mineral matter of all bones The amount of phosphorus in the earth's crust is small, being estimated at .11%. The amount required in the growth of plants on the other hand is considerable. The phosphorus in the corn kernel is .3 per cent, the percentage in the seed of plants being somewhat above that for the plant as a whole. Phosphorus, like nitrogen, is an element that under cultivation becomes deficient in soils.

Potassium:—Potassium is a constituent of many of the silicates and hence occurs like phosphorus in small amounts in the igneous rocks. The most important potassium minerals are the chlorides from which the commercial supply of potassium is derived. Potassium is relatively abundant in the crust of the earth, the estimated amount being 2.45%, or slightly more than magnesium. The amount required by the plant, however, is considerably more than of magnesium, and potassium, like nitrogen and phosphorus, frequently becomes deficient in soils.

Sulphur:—Sulphur is found native and also combined to form sulphides, sulphates, and other combinations. Pyrite and gypsum are the most common sulphur minerals. The total amount of sulphur in the earth's crust is estimated to be .11 per cent, or the same as of phosphorus. Recent investigations made by the Wisconsin Experiment Station indicate that the amount of sulphur required by plants is greater than has heretofore been supposed, and it is probable that under continuous cropping this element becomes deficient in soils.*

PLANT FOOD TAKEN FROM THE WATER AND FROM THE ATMOSPHERE.

Hydrogen:—Hydrogen occurs chiefly as water, H_2O, of which it forms about one-ninth part by weight. It is also a minor constituent of many other minerals, among which are the hydrated minerals, limonite, gypsum, and others. It is also a constituent of organic matter. The amount of hydrogen in the earth's crust to a depth of ten miles is estimated at .22 per cent. The amount in the ocean is 10.67 per cent. The amount of hydrogen used by plants is considerable, the kernel of corn being 6.4 per cent. hydrogen. The hydrogen used by plants is derived from the water absorbed by the roots. From the roots, the water passes through the stem to the leaves. In the leaves under the influence of sunlight the water is broken up into its constituent elements, hydrogen and oxygen, and is incorporated into the organic structure of the plant.

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*Sulphur Requirements of Farm Crops in Relation to the Soil and Air Supply, by E. B. Hart and W. H. Peterson. Research Bulletin No. 14, Wis. Exp. Station.

Water is thus doubly essential to plant life, since in addition to serving as an essential food it also acts as a carrier of food and probably for other purposes. All those elements already described as derived from the soil are carried to the plant in solution in the water which enters through the roots and is evaporated from the leaves. The evaporation of water from the leaves probably prevents an injurious rise of temperature. The amount of water thus passing through the plant is considerable. Important experiments in this connection were carried on in Wisconsin by King. Several crops were used in these experiments of which oats and corn may here be mentioned as illustrations. Seven trials on oats indicated an average of 557.3 pound of water evaporated per pound of dry matter formed. The average for eight determinations on corn was 275.6 pounds of water evaporated, per pound of dry matter formed.*

The water thus passing through the plant and acting mechanically as a carrier of food and for other purposes is not to be confused with the much smaller amount of water that is decomposed in the leaves and incorporated into the plant.

Oxygen:—Oxygen is the most abundant element, forming about one-half of all known terrestrial matter. It exists free as a gas in the atmosphere of which it makes up about 23 per cent. It is found in the atmosphere also in combination with carbon as carbon dioxide ($C O_2$), which makes up .04 per cent. of the atmosphere. In combination with hydrogen it forms water. Oxygen is a chemically active element, combines with about all of the other elements and is a constituent in many minerals, the most common of which are water, H_2O, siliceous sand, SiO_2 and the clays.

Notwithstanding its abundance as a constituent of minerals in the soil and as a free gas in the atmosphere, the oxygen used by plants is taken from neither of these sources. The oxygen used by plants is derived from reactions which occur in the leaves of plants when the carbon dioxide of the atmosphere acts upon the water from the soil.

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*Wisconsin Agricultural Experiment Station, 20th Ann. Rpt. p. 320, 1904.

The amount of oxygen consumed in building up the plant structure is relatively large, for instance, 46 per cent of the kernel of corn is estimated by Hopkins to be oxygen.

Carbon:—Carbon, although of great importance to plant life, occurs in relatively small amounts in the earth's crust. In the atmosphere carbon is found, as stated above, in combination with oxygen forming carbon dioxide gas. This gas occurs in small amounts, making up only .04 per cent. of the atmosphere, and the carbon itself constitutes only about .01 per cent. of the atmosphere. In the earth carbon occurs pure as graphite and diamond, as carbonate in limestones, and marbles, and as carbohydrate in organic compounds, coal, oil and gas. Carbon is estimated to make up .2 per cent. of the crust of the earth. Carbon is, like oxygen, one of the important elements in plant structure, the corn kernel containing, according to Professor Hopkins, 45 per cent. of carbon, or nearly as much as of oxygen.

All of the carbon used by plants is obtained from the carbon dioxide of the atmosphere. The carbon dioxide (carbon and oxygen) enters through the breathing pores of the leaf. Water (hydrogen and oxygen) also enters the leaf, coming from the roots through the stem. A chemical reaction occurs within the leaf by which is formed an organic compound, H_2CO. The excess of oxygen in this reaction passes off as free gas. This chemical reaction occurs only in the light and in the presence of chlorophyl, the green coloring matter of plants. The resulting compound is organic, not mineral, and represents that most important process, nature's laboratory for the manufacture of organic compounds, by which process, directly or indirectly, all life upon the earth is sustained.

It is worthy of note that all of the carbon used in plant growth is derived from the .01 per cent. of carbon in the atmosphere. In fact, the carbon of the atmosphere would be speedily exhausted were it not for a cycle by which carbon taken from the atmosphere is being restored again to the atmosphere. The decay of plants is a process of oxidation by which carbon dioxide is formed. In the case of herbs and annual plants the cycle is passed through ordinarily within one year. At the close of each growing season, much of the plant growth of the summer is subject to decay, and in the process of decay the carbon of the plant is oxidized and is returned to the atmosphere as carbon dioxide. The perennial plants have a longer cycle, which in case of trees, aside from the foliage, may last for many years, the carbon being temporarily locked up in the structure of the tree. In the form of coal, lignite, peat, muck, and limestones and other carbonates carbon may remain locked up in the earth for an indefinite period.

Moreover, animals feed upon plants and plant products, and the organic compounds are carried into the blood and there meet the oxygen taken into the lungs. The action in the lungs results in the formation of carbon dioxide which is given off in breathing. In addition to these usual sources the return of carbon dioxide to the atmosphere is being facilitated at the present time by the activities of man. This gas is a product of combustion as well as of decay, the two processes involving the same reactions. In the extensive use of coal, oil, gas, and wood as fuels the return of carbon dioxide to the atmosphere is being hastened. So also the calcining of limestone for lime and other purposes results in the return of carbon dioxide, the gas being given off when carbonates are heated.

The preceding pages contain estimates of the amount of the several essential elements in the crust of the earth to a depth of ten miles. These estimates are of value in a general way as bearing on the relative abundance of the elements, but it must be borne in mind that the amount in soils is not governed strictly by the relative amounts in the earth's crust. Some of the elements are relatively more abundant in the superficial than in the deeper deposits. Some are more readily soluble than others and hence are quickly removed from the soils by surface waters. Thus although the total amount of nitrogen in the earth's crust amounts to merely a trace too small to estimate, yet the small amount which does occur is largely in the soils, where it exists as a constituent of organic matter, ammonia or ammonium salts and nitric acid. The amount present in soils varies to such an extent that any attempt to express an average is practically useless. Nitrogen in soils to the amount of .01 to .03 per cent. is not uncommon, while soils rich in organic matter may contain 3 to 4 per cent. Certain soils of the Orinoco Valley in South America are said to contain as much as 30 per cent. of nitrogen. This is in the form of nitrates, and is due to the oxidation of organic matter through the agency of bacteria. The relative solubility of the ingredients materially affects their accumulation in soil. Potassium which occurs in soils in a readily soluble form, is often deficient in soils subject to leaching, although abundant in arid soils.

FERTILIZERS AND FERTILIZATION.

Fertilizers are plant foods added to the soils to supplement the natural plant foods. Of the ten elements essential to plant growth, three, carbon, oxygen, and hydrogen, making up 95 per cent. of the plant structure, are derived from sources other than the soil, namely, from water and from the air. The supply of these three elements is ample to meet all requirements. Of the seven elements taken from the soil four, calcium, iron, magnesium, and sulphur, are sufficiently abundant in soils to meet the requirements of plants. The three remaining elements, nitrogen, phosphorus, and potassium, frequently become deficient in soil, and require to be added. The application of fertilizer is commonly understood to refer to the addition of nitrogen, phosphorus, or potassium, in a form available to the plant.

The application of water to crops is known as irrigation. The application of calcium, as limestone, or lime, is known as liming the soil. In neither case, ordinarily, is the application intended to supply plant food, the water being applied as a carrier of food and the limestone or lime as a soil treatment.

CHEMICAL ANALYSES.

A number of chemical analyses of various Florida soils have been included in the body of this report. The interpretation of isolated analyses, however, must be applied with caution as they may lead through insufficient evidence to erroneous conclusions. The physical properties of soils, which can not be adequately indicated from isolated samples, are equally as important as their chemical properties. The soil moisture, the drainage and the possibilities of irrigation, the tilth of the soil and the climatic conditions are all important factors that must not be overlooked in rating the agricultural value of soils.

SOIL FORMATION.

ROCKS OF THE EARTH'S CRUST.

The rocks of the earth's crust from which soils are formed may be grouped under two main divisions, igneous (or primary) and sedimentary (or secondary.) The igneous rocks are those which appear to have cooled from a molten condition. The earliest rocks of the earth's crust are of this type, as well as the more recent materials brought up from deep within the earth by volcanic action. Secondary, or sedimentary rocks on the contrary, are those which have been derived either directly or indirectly from igneous rocks Chemical changes, however, are going on incessantly within the earth and affect all rock formations. Chemical and physical forces have in many instances so profoundly altered formations that it is no longer possible to determine whether they were originally igneous or sedimentary. For these the term metamorphic rocks has often been used.

IGNEOUS ROCKS.

The igneous rocks are very complex chemically, and include most of the chemical elements. In structure and mineralogical composition they are likewise variable. The structure is determined largely by the rate of cooling and other conditions under which the rocks were formed. When cooled quickly the time necessary for crystallization is not available and the rocks are of a glassy texture. When cooled more slowly various minerals are formed and the rock assumes a more or less distinctly crystallized structure. Volcanic ash and obsidian are examples of rapidly cooled rock; while the granites and similar coarsely crystallized rocks may result from a molten mass cooling slowly deep within the earth and under great pressure, which latter conditions favor a more perfect crystallization.

Mineralogically the igneous rocks are likewise complex. The presence of the chemical elements under varying conditions of cooling give conditions favorable for the formation of many minerals. The leading minerals formed under these conditions are the silicates, of which there are a great number. In addition to the silicates, sulphates, sulphides, phosphates, phosphides, chlorides, oxides and other minerals abound. Among the most abundant minerals in these rocks may be mentioned quartz, feldspars and the ferromagnesian silicates. The first of these, quartz, is to be noted in this connection as the mineral which, owing to its abundance and great resistance, remains as sand even after the disintegration and disappearance of most of the associated minerals. The feldspars break up through decay, furnishing the clayey element in soils, while from certain of the feldspars are derived also the potash so necessary to soil fertility. The ferromagnesian silicates include pyroxenes, amphiboles and mica. From these minerals soils derive the iron which is so large an element in the coloring of soils, and various other bases, as calcium and magnesium. Phosphorus is present in igneous rocks, although usually in small quantities in the form of apatite.

SECONDARY OR SEDIMENTARY ROCKS.

The secondary, derived, or sedimentary rocks are grouped into several classes determined by their manner of formation and chemical composition. These rocks are much less complex both in structure and in chemical and mineralological composition than the igneous rocks. They are derived from other rocks and in the process of reworking there is necessarily a selective separation of materials. The more soluble constituents of the original rocks are carried to the rivers, lakes and the ocean in solution, while the less soluble are mechanically transported and are separated according to specific gravity and size of particles.

Such common rocks as shales, sandstones, and conglomerates represent material mechanically transported and reaccumulated. The transporting agents are chiefly running water and the wind. The shales represent the finer sediments carried as mud, accumulated in quiet water and subsequently consolidated. The sandstones are the result of the accumulation of sands either by water or by the wind. After being accumulated these sands may become cemented and thus form sandstone. Sands accumulated on land by the wind form sand dunes in which the sand may remain in a loose uncemented condition or under certain conditions may be more or less perfectly cemented. The conglomerates are made of the heavier materials such as pebble and small rock, which is the first to drop out of suspension in running water. The clays, likewise, are in some instances mechanically accumulated, although many of the clays are residual, having formed in place from the decay of such clay-bearing minerals as the feldspars.

The clays and shales consist of a mixture of several minerals, among which hydrated aluminum silicates predominate. With these is found in varying quantities quartz, mica, and other minerals. Sandstones consist largely of quartz sands, while the conglomerates may be of any material, although flint pebbles usually predominate.

The limestones in the secondary formations are either of chemical or organic-chemical origin. The bases, calcium and magnesium, are taken into solution and carried by running water to the lakes and the ocean. Subsequently under certain conditions they may be precipitated from the water to form limestone, thus constituting the chemically formed limestones. More frequently, however, organic processes are involved, the constituents being taken from the water through the agency of organisms, chiefly shells and corals, which have the power of extracting from solution the materials from which the calcareous skeleton is built. After the death of the animal the skeleton remains to form the limestone. Shells accumulate in this way to form the shell limestones, and corals in some instances accumulate to form a coral limestone. The foraminifera, animals having a minute calcareous shell, accumulate in such abundance as to make up extensive limestones, the formation known as the Vicksburg Limestone underlying Florida, being composed in places chiefly of these small shells. The oolitic limestones such as the Miami Oolite in southern Florida is probably chiefly chemically formed. although many shells and some corals are included.

The term marl is somewhat loosely applied to calcareous formations, several varieties of which are found in Florida. When consisting largely of shells these marls are known as shell marl. Some of the marls which accumulated in bogs contain few or no shells, having been apparently chemically formed.

Some of the other secondary rocks are purely of chemical origin. Among these may be mentioned the bog iron ore frequently found in old swamps. The iron in these deposits has been brought into the swamps in solution and subsequently precipitated owing to the organic acids present in swamp water. The flint masses found frequently in limestone formations are due to segregation of silica through chemical action.

Owing to the assorting processes which accompany the formation of the secondary or sedimentary rocks, they are, as previously stated, much less complex chemically than are the igneous rocks. This absence of chemical complexity has an important bearing on the formation of soil, and there are well-marked differences to be noted between soils derived from igneous and those derived from sedimentary rocks.

The formations found in Florida from which the soils are derived are of sedimentary origin. Since there are many different kinds of sedimentary rocks the soils from them are necessarily varied. Moreover, the character of the soil is determined not alone by the formation from which derived, but also by the climatic, drainage and other conditions to which it has been subjected. Distinct formations if similar in character may give rise to similar soils. Conversely, a single formation under varying conditions may give rise to various soils. If the writer's views as to the origin of the sandy soils of the interior of the State are correct, soils in Florida referred to the Norfolk, Portsmouth, and Orangeburg series are in some instances derived from one and the same formation, the differences in the soils being due to the different topographic and drainage conditions under which they have accumulated.

DISINTEGRATION OF ROCKS.

Soils result from the decay and disintegration of rocks. Active among the agencies of decay are: Changes of temperature; frost or freezing; wind; water; animals; and plants. Through the continued activity of these agencies, solid rocks crumble to dust, the residue forming the mineral constituents of soils. The combined effect of all these agencies is known as weathering, and all rocks when exposed at the earth's surface are subjected to this process.

CHANGES OF TEMPERATURE.

Changes of temperature of rocks result in alternate contraction and expansion, thus widening existing breaks and joints, loosening the rocks and permitting the entrance of water, which finds its way more readily through the rock. In dry climates rocks heated to a high temperature during the day cool rapidly at night. Under the influence of heat rocks expand, and the sudden cooling and contraction of the exterior crust upon the still heated and hence expanded interior sets up strains which frequently disrupt and break the crust. Then, too, rocks consist usually not of one but of several minerals, and each mineral has its own coefficient of expansion and contraction and hence contracts and expands when heated, at a slightly different rate from the associated minerals. Thus the different parts of the rock are subjected to strains, which loosen the minerals and let water enter more freely, thus hastening decay.

FROST AND FREEZING.

Aside from the ordinary changes of temperature, freezing in the colder latitudes is an active destructive agent. When water freezes it expands with almost irresistible force. The breaks, crevices, and pores of rocks are filled with water as a rule, and when this freezes, the force of expansion of the water enlarges all such openings, thus hastening the decay of the rock. Decay from freezing takes place most rapidly as will be apparent, at seasons of the year when alternate freezing and thawing occurs frequently, as when the surface rocks thaw during the day and freeze at night. Owing to the mild climate this factor in the decay of rocks is of minor importance in Florida.

WIND.

The wind as a weathering agent might at first thought, seem to be of little or no importance, yet under favorable conditions the sand, fine gravel, and other materials, carried by the wind may be hurled with considerable force against the face of exposed rocks and thus gradually wear them away. The wind is most active as an agent of decay in the deserts and other sections of slight rainfall. Under the action of the wind the softer materials wear away first. Also, since heavier materials carried by the wind are carried close to the ground, the base of exposed rocks are worn more rapidly than other parts, resulting in fantastic sculpture as seen in some of the desert rocks.

WATER.

The agencies mentioned, changes of temperature, frost, and wind, all exert a purely mechanical effect in the disintegration of rocks. Water, however, in its various phases of activity, acts both mechanically and chemically. Falling as rain, water has but feeble mechanical effect, although in the form of running water a greater mechanical action is exerted, not by the force of the water alone, but more particularly by the force of the impact of materials thrown by the current against the face of exposed rocks along the bottom and the sides of the stream. The mechanical action of water is in this respect analagous to that of the wind. The waves of the sea and of the large lakes carry on mechanical erosion by the force of impact of the waves beating on the shore.

The chemical action of water is vastly more effective in the disintegration of rocks than the mechanical. Rocks consist ordinarily, as previously stated, of a mixture of minerals, and while all minerals are to some extent soluble, some are much more readily soluble than others. When these soluble minerals are removed in solution, the rock necessarily crumbles. Water is more effective as a solvent beneath than above the surface. Rain water upon passing through the atmosphere and entering the earth, takes into solution more or less of the gases, carbon dioxide and oxygen. From the decaying vegetation in the earth it receives also various organic acids, all of which materially increase its solvent action. For this reason many rocks that are little affected by solution above ground are disintegrated beneath the surface.

Some chemical reactions in which water takes no actual part nevertheless take place much more readily in the presence of moisture. This is particularly true in the process known as oxidation, which is a very important factor in the disintegration of rocks. Oxidation is the chemical reaction between the free oxygen of the air and various minerals in the rocks. This reaction, as previously stated, takes place much more readily in the presence of moisture, and slowly or not at all in the absence of moisture. The effect of oxidation is the formation of new minerals. Oxidation does not necessarily bring about decay, since the oxidized form of minerals is more stable than most other forms. Indirectly, however, it results in the breaking up of rocks. If, for instance, rocks exposed at the surface, contain sulphides, these on exposure are likely to be oxidized to oxides and the solidarity of the rock destroyed.

Hydration is also an important chemical reaction accompanying decay of rocks. Hydration is the chemical reaction by which water is taken into chemical union by the mineral, thus forming in reality a new mineral. When hydrated a mineral is found to occupy more space than in the non-hydrated condition. Not all the minerals in a rock as a rule are subject to hydration, but the increased space occupied by the hydrated minerals results in the disintegration of the rock.

The destructive effect of water in the form of ice sheets, although not effective in Florida, has been of importance in glaciated regions. Glaciers are found at the present time both in the arctic and in the antarctic regions, and in former times they were of greater extent. During the glacial period immense sheets of ice moved southward extending, in the central part of the United States, as far south as the Ohio River Valley. The action of glaciers is characteristic. The ice sheet moving slowly holds the smaller rocks firmly and pushes them slowly over the stationary underlying rocks, grinding the rocks to a fine powder, which subsequently re-accumulate as soil materials. The glacial soil is often rich, consisting as it does of rocks thus artificially ground, having been less affected by the dissolving and assorting power of water than other soils.

PLANTS AND ANIMALS.

The action of plants and animals in the disintegration of rocks and the formation of soils is important. The roots of plants penetrate the rock crevices and as they grow pry apart the rock, thus enlarging the opening. Seeds of plants likewise fall into crevices and by their growth open wider the natural breaks in the rock. Moreover, the roots of plants secrete acids which act as a solvent on the rock. Some marine animals bore into the rocks, while on land many different animals bore into the soil, thus bringing the deep and less thoroughly disintegrated soil to the surface, and also permitting the rainfall and the air to have free access to the deeper soils. In Florida the so-called salamander, a small rodent, *Geomys tuza floridanus,* bores extensively in the sandy soils. This animal however, is adverse to moist conditions, and inhabits only the sandy well-drained lands. In the moist low lands the cray fish are the most conspicuous borers, bringing up large amounts of the sub-soil to the surface. This type of land is familiarly known as "crayfish" land. Among the other borers which affect soils may be mentioned the earthworms, ants and "gophers", the last mentioned being a term applied in Florida to a species of land tortoise.

ACCUMULATION OF DISINTEGRATED MATERIAL.

The material resulting from the disintegration of rocks may remain in place as formed, or may be transported a greater or lesser distance. The agencies of transportation are numerous. The work of boring animals and of plants referred to above assist in the transportation of soils by loosening the material and bringing it to the surface. The wind is an agent in transportation, the finer particles of the soil being freely moved by the wind. The extensive line of sand dunes bordering the Florida coast are chiefly wind blown. The valleys and depressions are continuously receiving small additions of fine sand and dust particles blown in by the wind. The chief agent of transportation of soils, however, is water, the amount of soil transported by water being much greater than that of all other factors combined.

CLASSIFICATION OF SOILS.

A satisfactory classification of soils is difficult and the subject may be approached from any one of several different standpoints. A common system of general classification is that in which the soils are classified in accordance with their manner of formation, as residual, transported, or colluvial.

RESIDUAL SOILS.

The residual soils are those which have formed in place. In this class of soils the parent rock from which the soil is derived lies beneath the surface at a variable depth, depending upon the intensity and duration of the weathering processes and upon the surface contour. On steep slopes little or no soil accumulates, being removed by surface wash. On the more gentle slopes if the weathering processes have been long continued soil may accumulate to a great depth. The residual soils partake to some extent of the characteristics of the formations from which they are derived. Thus a sandy formation upon decay gives rise to sandy soils. Clays give rise to clay soils. The chemically complex rocks such as the granites and other igneous rocks give rise to soils which include a variety of minerals. Limestones are largely dissolved in the processes of soil formation, the resulting soils being formed almost entirely from the impurities which the limestones contained.

The typical residual soils are those which have formed from the decay of igneous rocks. Such soils possess certain distinctive characteristics due to the fact that they are formed from rocks that are chemically and mineralogically complex, and from the fact that the soil materials have in no stage been subjected to the assorting power of wind or water. Those soils which have formed in place from sedimentary rocks are here designated as residuo-sedimentary.

RESIDUO-SEDIMENTARY SOILS.

The residuo-sedimentary soils differ from the typical residual soils in that they are derived from rocks the materials of which in a previous stage of disintegration were more or less perfectly assorted by wind or by water. To this extent the residuo-sedimentary soils resemble transported soils. As the igneous rocks are complex chemically and mineralogically, the soils arising from them are likely to share more or less in this complexity. The sedimentary rocks, having been affected at the time of their deposition by the assorting power of wind or water, give rise to soils less complex mineralogically, and probably also less complex chemically. The residuo-sedimentary soils are of special importance in Florida. much the greater area in this state having soils of this type.

All soils are subjected after their formation to a limited amount of assorting of materials. The readily soluble materials, except in exeedingly dry climates, pass away in solution. The finer materials in the soils in sections of heavy rainfall are to a considerable extent removed from the soils by percolating waters. Both solution and mechanical transportation have affected the soils of Florida. The rainfall over the entire State is heavy and the removal of the finer clay particles is an important factor in the formation of the sandy soils of the interior of the state.

TRANSPORTED SOILS.

Transported soils are those which have been transported from the place where originally formed and reaccumulated at another locality. The importance of this process arises from the fact that in being transported the soil materials are subjected to more or less assorting. The alluvial soils of the river valleys are accumulated in this way, the alluvium being the finer material carried by the water. Soils may be transported by water as the alluvial soils, or by the wind. The latter are known as æolian soils.

COLLUVIAL SOILS.

The colluvial soils are those which have been slightly removed from the place where originally formed and more or less intermixed with other soil materials. They are found chiefly along hillsides, being due largely to creep of the soils and to slides which carry the soil to a lower level and mix it with other material. The chief distinction between colluvial and transported soils lies in the fact that the colluvial soils have not been subjected to the assorting of materials which is characteristic of the transported soils.

Surface wash by running water has an important bearing on soil formation. By this means soils are frequently transported and the mineral constituents more or less perfectly assorted. Along steep slopes surface wash is often so effective that no residual material can accumulate to form soils, and on less steep slopes the soil is materially affected by the removal of the finer ingredients. Even on level surfaces, under certain conditions of sub-drainage, the finer materials of the soil are segregated from the coarser.

OTHER TERMS DESCRIPTIVE OF SOILS.

A classification of soils in common use is that which refers to the soil ingredients rather than to the manner of formation. The clay soils are those in which clay predominates. Sandy soils are those in which sand is an abundant mineral constituent. Silty soils consist of finer material, including fine sand and finely divided clay. Loams are those soils having an admixture of sand and clay. Other terms as calcareous, ferrugineous and muck soils are self-explanatory. The clay soils are often referred to as heavy, and the sandy soils and loams as light, referring to the ease with which they may be cultivated. The heavy soils, although more difficult to farm, are frequently very durable owing to their clay ingredients, the decomposition of the clay minerals supplying plant food.

As has been previously stated, the presence of water in soils retards oxidation and preserves a high constituent of organic matter. Under favorable conditions a considerable thickness of vegetable matter more or less decayed accumulates from the growth of vegetation, forming muck deposits. The muck, therefore, accumulates wherever the vegetation is dense and there is sufficient water covering the surface to prevent the oxidation of the vegetable matter. The muck deposits of Florida are extensive. Peat is likewise essentially an accumulation of vegetable matter which has been preserved from decay by being immersed in water containing organic acids. It is customary to apply the term "muck" to vegetable material that is available, after being drained, for agricultural purposes. Peat is reserved for thicker accumulations of vegetable material which, being largely immersed under water, are not in a rotted condition, or at least not more than a surface coating is so rotted. Muck is also applied to vegetable material that may be high in clay or other impurities.

SOIL NAMES IN USE BY THE BUREAU OF SOILS OF THE THE UNITED STATES DEPARTMENT OF AGRICULTURE.

For convenience of description and reference specific names are applied to soils. The most extensive system of soil nomenclature now in use is that established and followed by the Bureau of Soils of the United States Department of Agriculture. According to this system the whole territory of the United States is divided into thirteen physiographic divisions designated as soil provinces. The soils in each province are grouped in certain main divisions designated as soil series. Each series in turn includes one or more soil types.

The soil series is defined as including soils that are alike in origin, color, and in some physical properties.

The soil type or soil name is a more definite unit than soil series and applies to a particular kind of soil within the series. The soil name is formed by adding to the name of the series a term descriptive of the soil. Thus Norfolk sand refers to a soil in the Norfolk series in which both soil and sub-soil are a sand. Similarly Portsmouth sand refers to a soil of the Portsmouth series having a sandy top soil and sub-soil. The texture of the soil may be further indicated by introducing a descriptive term such as coarse sand, fine sand or very fine sand. In describing soils the depth of three feet is taken as a standard, and if a clay sub-soil is found within this depth the soil is termed a loam. Norfolk sandy loam thus means a sandy top soil and a clay sub-soil within a depth of three feet or less. Portsmouth sandy loam or fine sandy loam refers to soils of the Portsmouth series having a clay sub-soil within three feet of the surface.

Florida lies within the coastal plains province. In this province. which extends along the Atlantic and Gulf coasts from Long Island to Louisiana, nineteen soil series have been recognized by the Bureau of Soils. Only a limited part, about ten per cent, of this area has been surveyed in detail and additional soil series are likely to be established as the soil surveys proceed. In Florida detailed soil surveys have been made by the Bureau of Soils in seven areas as follows: Escambia, Gadsden, Jefferson and Leon Counties, and parts of Alachua, Duval and Jackson Counties. The total area surveyed in Florida includes about 3,000 square miles. Within this area five series and twenty-eight soil types have been recognized. The five series are the Norfolk, Orangeburg, Portsmouth, Myatt, and Gadsden.

NORFOLK SERIES.

The Norfolk series includes light colored sandy soils with yellow sand or sandy clay sub-soils. The Norfolk soils are found on comparatively level or gently rolling lands, or at least on lands not subjected to surface wash, although well drained. No fixed grade can be given at which surface wash would be sufficient to remove the light sands, as this is determined by texture and thickness of the sand. Sand dunes and other accumulations of sand may be relatively steep and yet not wash. The soil types in the Norfolk series described in Florida are Norfolk sand, coarse sand, fine sand, loam, sandy loam, fine sandy loam, and very fine sandy loam. The Norfolk is by far the most extensive series in Florida. Of the total area mapped in detail by the Bureau of Soils, about 65% is referred to the Norfolk series. In the state as a whole probably not less than 75% of the soils will in this system be classed in the Norfolk series.

ORANGEBURG SERIES.

The Orangeburg series differs from the Norfolk series in having a red sandy clay sub-soil instead of a yellow or blotched subsoil. The top soil of the Orangeburg series may be light colored, although it is usually red, due to admixture of material from the red clay subsoil. The Orangeburg soils, as a rule occupy the slopes, while the Norfolk soils usually rest upon more level ground. The Norfolk soils are subjected to little or no surface wash and the constant seepage of surface waters removes most of the clay particles, leaving the light colored sandy soils. The Orangeburg soils lying upon the slopes are subjected to more rapid change than the soils on level ground, and the renewal of new soil material from the sub-soil is proportionately more rapid. The soils moreover, are not so long exposed to the leaching processes that remove the soluble constituents. For this reason the soils on hillside slopes, if prevented as they easily are from destructive surface wash, are, other conditions being the same, more enduring than those on the level lands.

The types of Orangeburg soils that have been recognized in Florida are the following: Orangeburg sand, coarse sand, fine sand, loam, sandy loam, coarse sandy loam, and fine sandy loam. The areas of chief distribution of the Orangeburg soils are the red clay hills of northern, western and central Florida.

PORTSMOUTH SERIES.

The soils of the Portsmouth series contain more or less organic matter which give them a dark color. The sub-soil may be gray, yellow, or mottled yellow and gray. Mottled sandy clays form the sub-soil of the loams of this series. For agricultural purposes the Portsmouth soils, as a rule, require drainage.

The differences between the soils of the Norfolk and the Portsmouth series are due primarily to differences in the drainage conditions from which arise other differences in the chemical and physical properties. The Portsmouth soils are poorly drained. During a part of the year they are more or less flooded, and during all of the year the water table stands at or very near the surface. The moist condition of the soil retards oxidation of the grasses and other vegetation, the accumulation of which adds organic matter to the soil, giving the dark color. Further chemical changes result from the presence of the organic matter and the undrained condition of the land, the mottled sub-soils being due to this cause. When drained, the Portsmouth soils are frequently desirable for farming purposes, the organic matter already stored in the soil, adding fertility. These soils are being extensively used, after drainage, as trucking soils. The following soils of the Portsmouth series have been recognized in Florida. Portsmouth sand, fine sand, sandy loam, and fine sandy loam.

MYATT SERIES.

The Myatt series is established for soils which occur in seepy places around the heads of streams or on slopes. The soils are gray, the sub-soils gray and yellow mottled with white. In the soil survey reports on the areas surveyed in Florida only one type of the soils of this series is described, the Myatt fine sandy loam, and this occurs only to a very limited extent.

GADSDEN SERIES.

The Gadsden series includes dark-gray soils found upon gentle slopes or undulations adjacent to streams. The soils of this series are regarded as colluvial, resulting from the creep or wash of materials from a higher level. The series is based upon the Gadsden sand and the Gadsden sandy loam first described from Gadsden County, Florida. This series is of limited extent.

MISCELLANEOUS SOIL TYPES.

A number of miscellaneous soil types not yet referred to a series have been recognized by the Bureau of Soils, in Florida. In addition to swamp, meadow, sandhill, coastal beach, marsh and muck lands, these are as follows: Greenville clay, Greenville sandy loam, and Greenville loamy sand; Gainesville sand; Leon fine sand; Ocklocknee clay; Plummer fine sandy loam, and Grady fine sandy loam. The total combined area of these miscellaneous types, however, is small as compared with the leading soil series already described. As detailed soil surveys proceed other soil types will doubtless be recognized and described.

SOIL LITERATURE.

The most accessible and reliable literature on the soils of the state is that which has been issued by the various State and Government bureaus. The Florida State Experiment Station has issued a number of reports bearing on various phases of soil conditions and soil utilization. Among these are the following: A Chemical Study of Some Typical Soils of the Florida Peninsula, by A. A. Persons, Bull. 43, 1897; Pineapple Culture, Soils, by H. K. Miller and H. H. Hume, Bull. 68, 1903; Soil Studies, 1, by A. W. Blair, Bull. 87, 1906; Soil Studies, 11, by A. W. Blair, Bull. 93, 1908. The reports of the State Department of Agriculture include many references to soils. and in the various reports of the State Chemist will be found many soil analyses. The reports of the United States Department of Agriculture contain many general soil studies and a few reports relating specifically to Florida. The special reports include: A Preliminary Report on the Soils of Florida, by Milton Whitney, Bull. 13, 1898; and the detailed surveys and maps, a list of which has already been given. The areas mapped include Escambia, Gadsden, Jefferson, and Leon Counties, and parts of Alachua, Jackson and Duval Counties.

The general literature on soils is extensive. Among the numerous text-book and treatises on soils the following recent publications will be found instructive:

GENERAL PUBLICATIONS ON SOILS.

Hilgard, E. W.—Soils. Their Formation, Properties, Composition and Relations to Climate and Plant Growth in the Humid and Arid Regions. The Macmillan Company, 1906.

Hopkins, Cyril G.—Soil Fertility and Permanent Agriculture. Ginn and Company.

King, F. H.—The Soil. Its Nature, Relations, and Fundamental Principles of Management. The Macmillan Company.

King, F. H.—Farmers of Forty Centuries, or Permanent Agriculture in China, Korea and Japan. Published by Mrs. F. H. King, Madison, Wis.

Merrill, George P.—Rocks, Rock-weathering and Soils. The Macmillan Company, 1906.

SOIL TYPES IN FLORIDA.

While the soils in Florida are extremely varied, yet for the purposes of a general survey, representative sections of country may be recognized in which particular types of soil predominate. The divisions that are here recognized are based upon the vegetation and upon such other characters as may be easily observed, including the drainage conditions, the amount of organic matter in the soil, and the character of the soil and sub-soil.

The terms used for the different sections are descriptive merely and are not used as technical names for soils. The actual naming and mapping of soils can proceed only as detailed soil surveys are made.

Among the varied types of land are the pine lands, alluvial, prairie, swamp, marsh, muck and hammock lands of several kinds.

PINE LANDS.

About 70 to 75 per cent of the total land area of Florida was covered originally by pine forests. In northern, central and western Florida the long leaf, or yellow pine, *Pinus palustris,* is the prevailing forest tree, while in southern Florida, the Cuban pine, *Pinus caribaea,* predominates. The short leaf pine, *Pinus echinata,* grows in the hammock types of country in association with deciduous trees. The same is true of the spruce pine, *Pinus clausa,* which grows extensively on quiescent dunes bordering the coast. A few other pine species are found, but they occupy less extensive areas. The pine lands are varied and several more or less distinct types may be recognized.

ROLLING PINE LANDS.

The rolling pine lands include well drained areas, also known as high or upland pine. This is an extensive type of country and is itself varied in soils and topography. The prevailing forest tree is the long leaf pine. As a rule there is little or no undergrowth, although in the more sandy localities, small oaks are found. Saw palmetto occurs rarely and only to a limited extent.

The top soil in the rolling pine lands is light colored or gray, or dark from admixture of organic matter. The depth to the clay is variable and several grades of soil in this type of country are recognized, depending chiefly upon the texture of the soil, drainage conditions, and the character of the sub-soil. In some sections the underlying sandy clay is found at a depth of one to two feet. In these areas if well drained the clay usually contains iron pebbles and is oxidized red in color. Elsewhere the clay lies from three to six or more feet beneath the surface ,and in the extremely sandy soils the clay lies at an undetermined depth.

The superficial sands which form the top soils of the upland pine lands have very generally been held to be a formation distinct from and later than the underlying material. This view the writer believes untenable. The parent formation of the soil is the underlying sandy clay, the dinistegration of which has given rise to the sands according to the usual processes of soil formation.

The depth to which the sandy clay has disintegrated is determined chiefly by the topographic and drainage conditions. Underground water is the chief disintegrating agency. The rainfall passes into the earth and emerges by seepage along the hillsides. In this course of circulation certain of the cementing constituents of the sandy clay are dissolved out, and also the minute clay particles, which act as a binder, are carried mechanically to a lower depth. By this process the covering of loose surface material and soil is continuously deepened.

This process of disintegration is carried on, other conditions being the same, most actively where the water table lies several feet beneath the surface, and where the sandy clays rest upon limestone, or where the surface is sufficiently broken to give good drainage. Obviously, however, where the surface is so far broken as to permit surface wash, no loose sands accumulate, since they are removed as rapidly as formed. It is true, also, that the parent sandy clay is not of uniform character, but is more sandy and is more easily disintegrated in places, while elsewhere the percentage of clay is greater and the disintegration proceeds more slowly. The disintegrated stratum in a cross section of a hill may be seen as a rule to follow to a degree, the contour being thickest usually on the top of the hill unless affected by the surface wash, and thinning out at the sides in proportion to the steepness of the slope.

Some of the very desirable general farming lands are found in the belt of rolling pine lands. This is true in particular of those soils having clay sub-soil within a few feet of the surface. Other sandy soils in which the clay is not within a determinable depth are less productive, although even these more sandy soils under proper cultivation are made to yield satisfactory returns. In the heavier types of soils having a clay sub-soil near the surface the pine

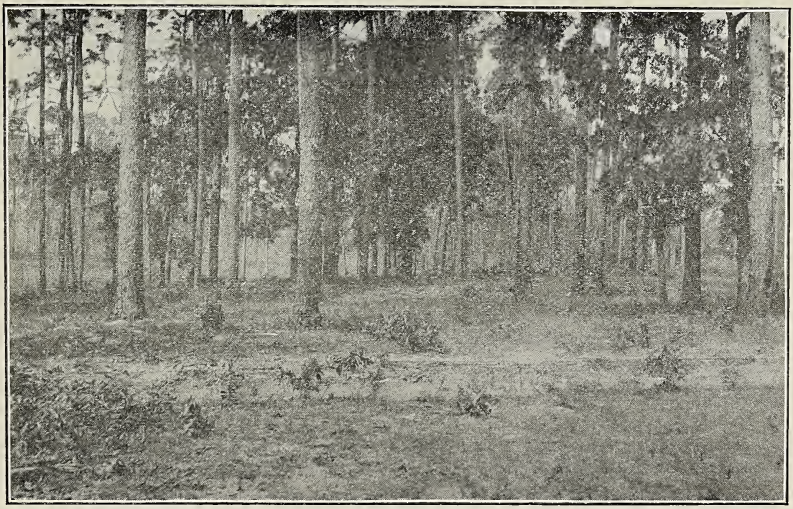


Fig. 1.—Well drained pine land, two miles south of Mayo in Lafayette County. The prevailing timber growth is long leaf pine.

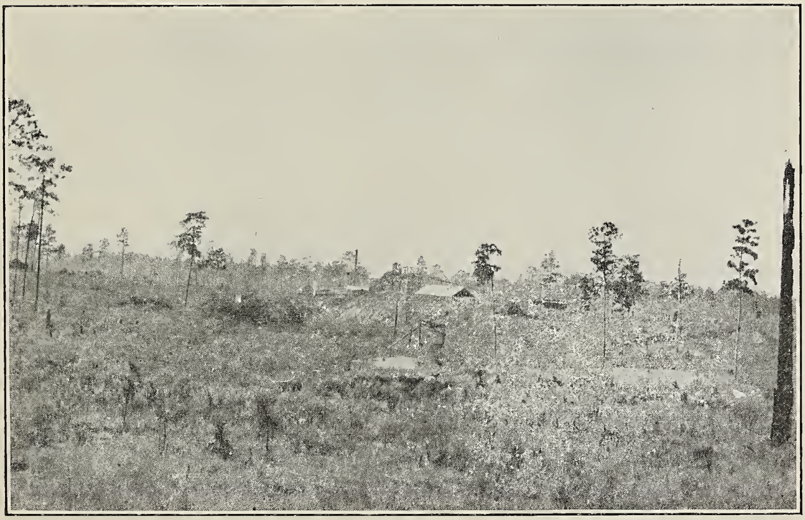


Fig. 2.—Well drained sandy pine land in the phosphate belt of Marion County, near Juliette.

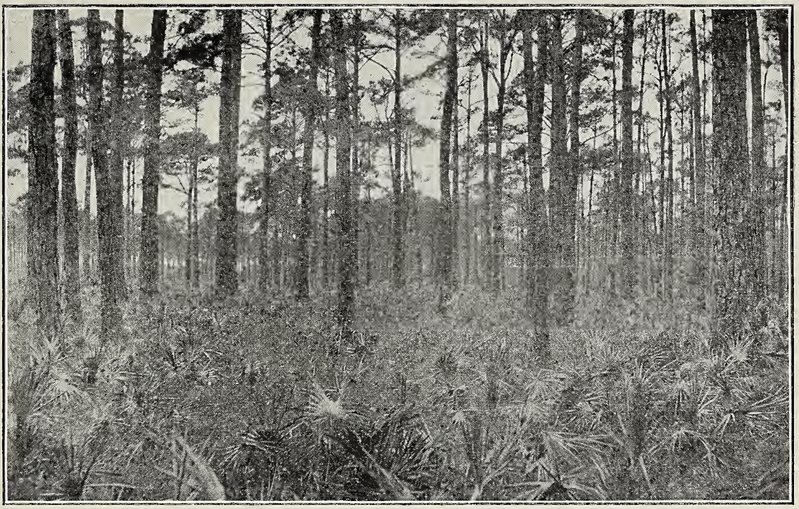


Fig. 1.—Typical Palmetto flatwooas.

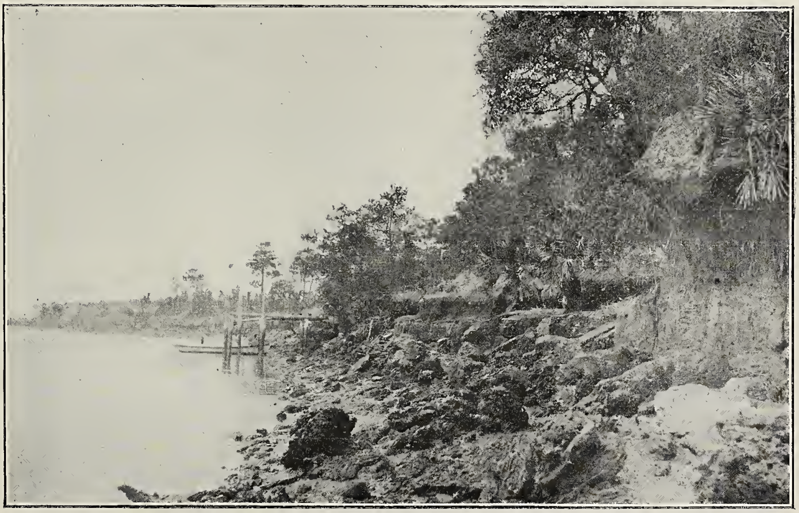


Fig. 2.—Exposure of hardpan underlying flatwoods at Black Bluff on Clark's Creek in Nassau County.

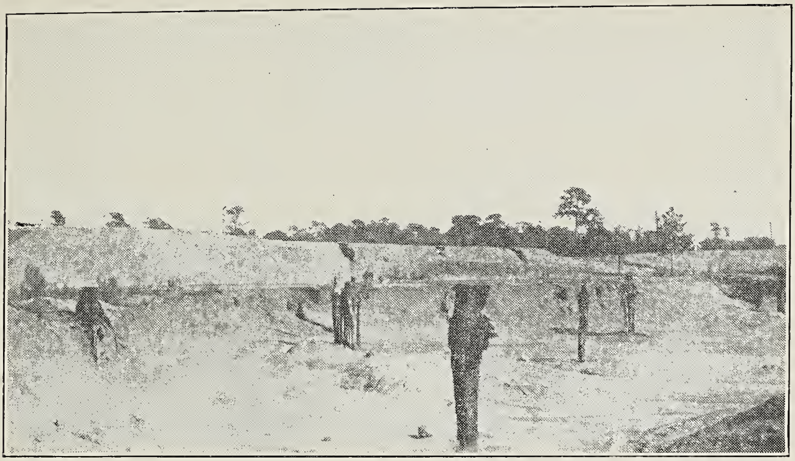


Fig. 1.—Long leaf pine (**Pinus palustris**), grown in well drained sandy land, showing the well developed tap root. Photograph taken at the pit of the Dunnellon Phosphate Company near Hernando, Citrus County.

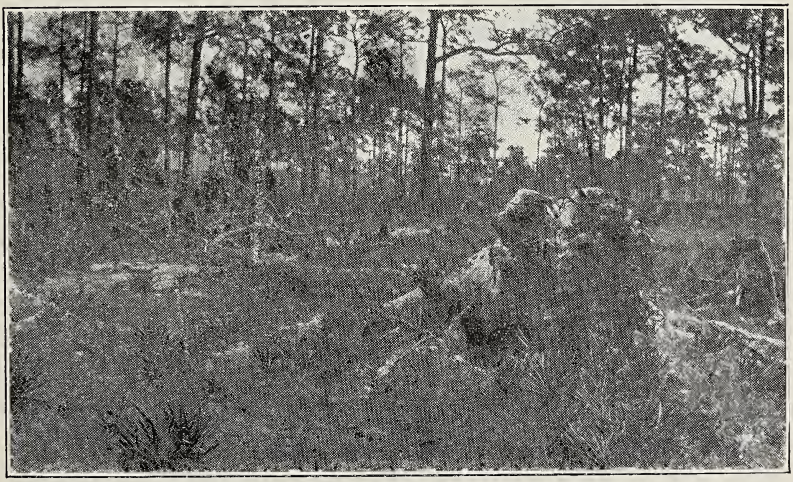


Fig. 2.—Long leaf pine growing in palmetto flatwoods, showing the absence of tap root owing to the underlying hardpan.

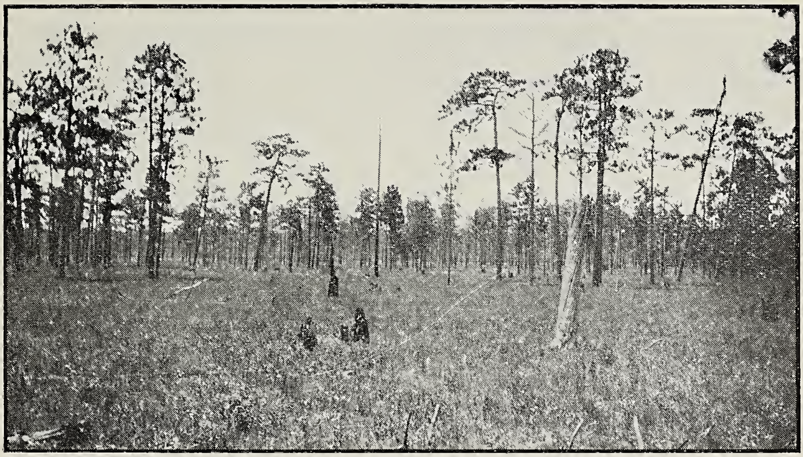


Fig. 1.—Open flatwoods. Photograph taken near DeLeon Springs, in Volusia County.

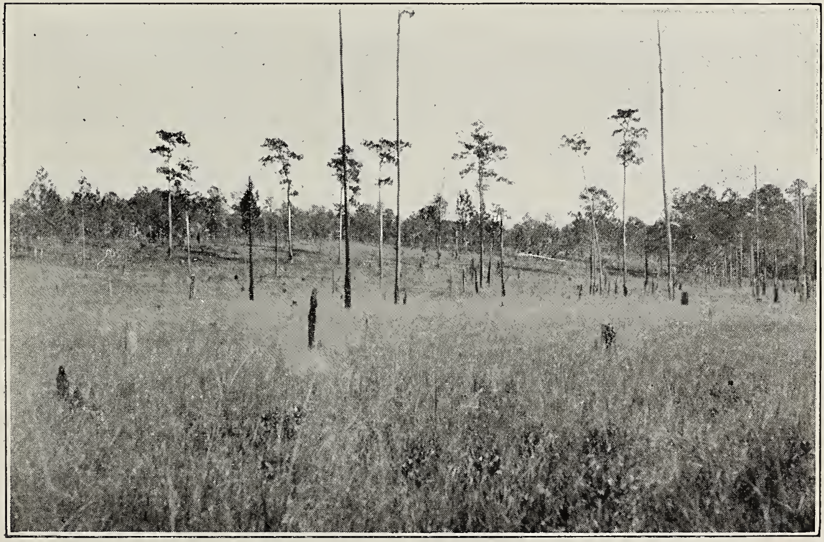


Fig. 2.—Open flatwoods in Nassau County showing rise to higher land in the background. Photograph taken by L. W. Stephenson.

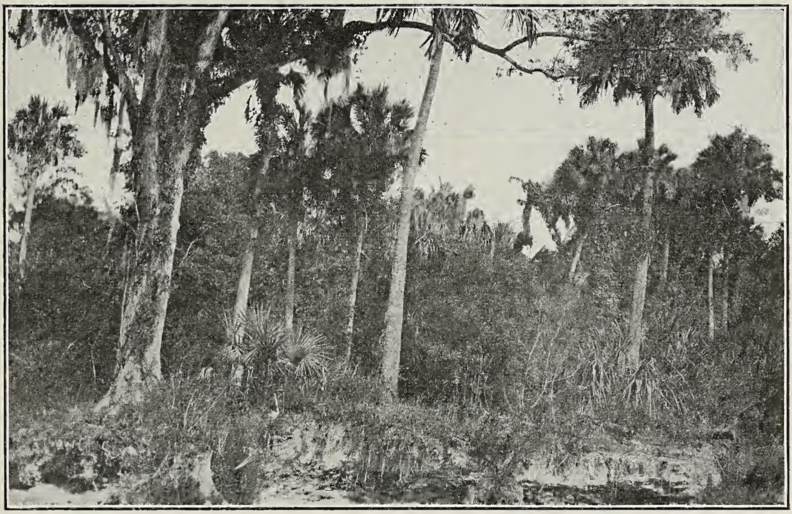
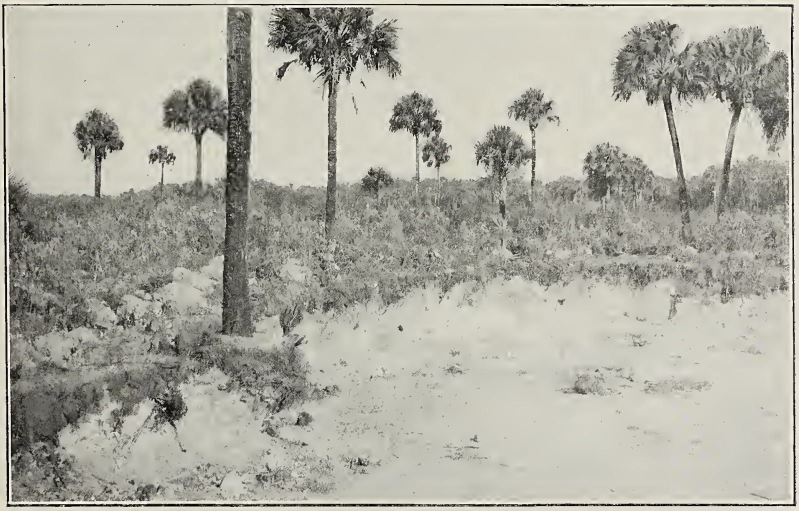


Fig. 1.—Calcareous hammock land. Photograph taken in Turnbull hammock, one mile west of Daytona. The underlying material here is shell marl.



Fg. 2.—Calcareous hammock land, nine miles east of Ft. Myers, in Lee County. The underlying material here is a marl.

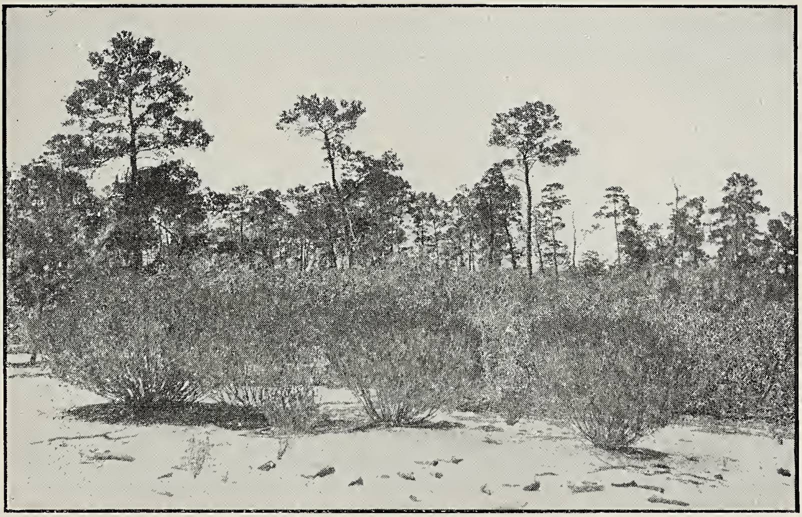


Fig. 1.—Sand dune supporting a scrub growth on east side of Lake Kingsley in Clay County. The sand here is unusually light colored and is free from clay ingredients.

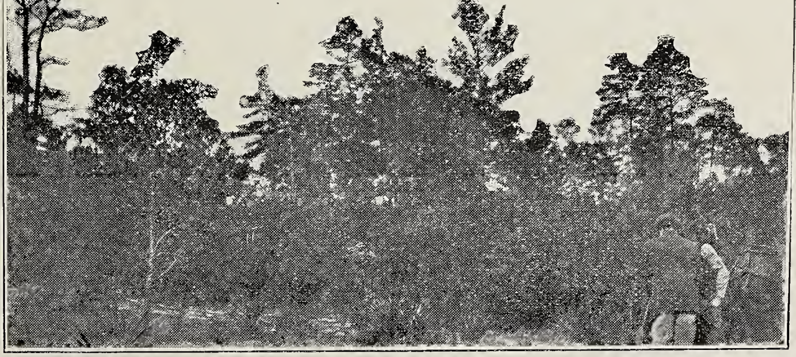


Fig. 2.—The Big Scrub south of Ocala in Marion County. View taken at the border of the scrub showing the abrupt transition from pine land to scrub.

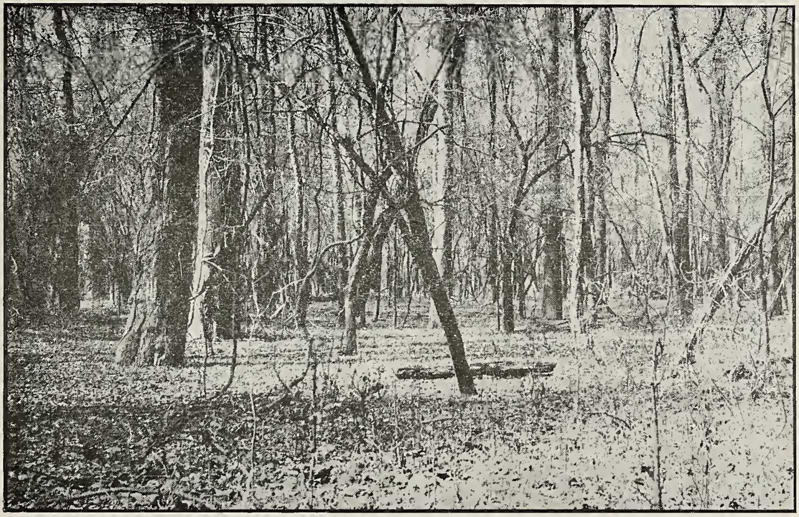


Fig. 1.—Alluvial land of the Apalachicola River in the northern part of Liberty County. Photograph taken by R. M. Harper.

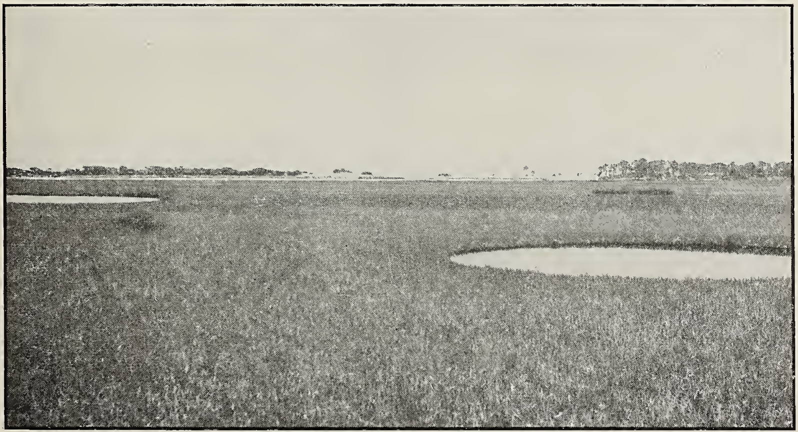


Fig. 2.—Salt marsh near Mayport, Duval County. Photograph by R. M. Harper.

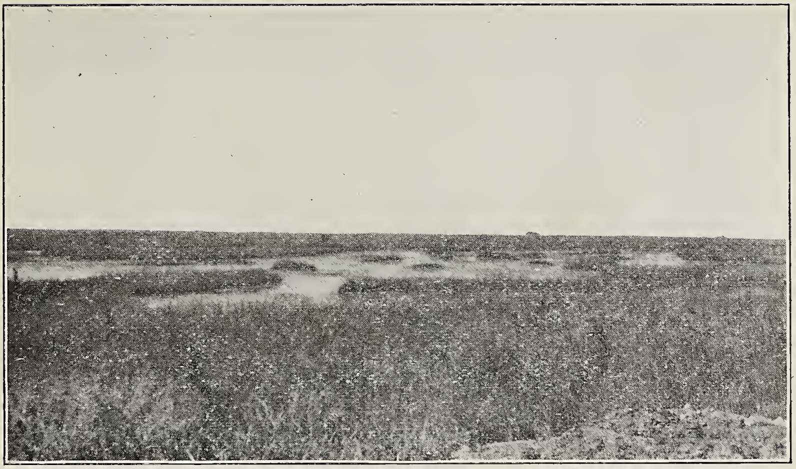


Fig. 1.—Everglades of Florida west of Fort Lauderdale. Photograph taken by H. Gunter from dredge "Okeechobee."

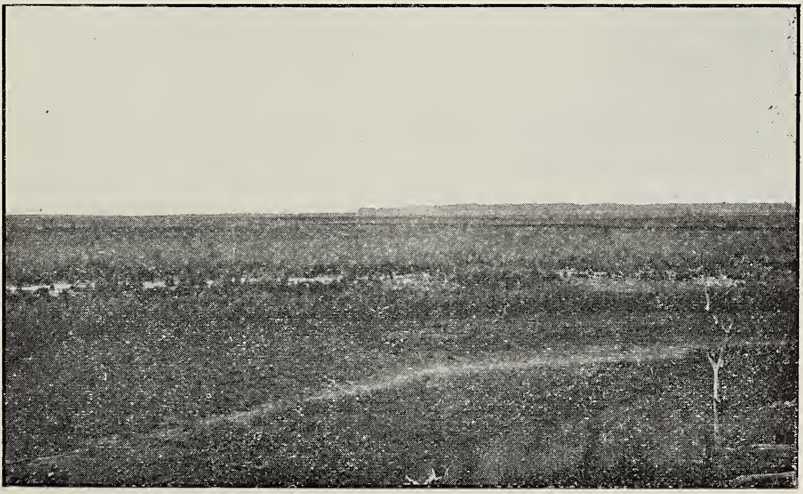


Fig. 2.—Paynes Prairie, near Gainesville, in Alachua County. Photograph by R. M. Harper.

when removed will re-forest itself naturally, but on the very sandy soils the pine when cut off is quickly replaced by a dense growth of scrub oaks.

The rolling pine lands are too extensive to call for specific reference to areas. The interior of the State is chiefly of this type. A large number of soil types are included which can be properly separated and mapped only by detailed soil surveys. The pine lands in the limestone sections of the State present many differences in topography, in drainage, and in the grade of soils, from the pine lands in the non-limestone sections.

The following is an analysis of a sample of the well drained pine land of Osceola County. The principal vegetation is pine and scattered oak, and wire-grass. The sample was collected by R. E. Rose. The analysis is taken from Bulletin 43 of the State Experiment Station.

Analysis of Virgin High or Rolling Pine Soil and Sub-soil.

	Soil.	Sub-soil.
Coarse earth	.90	.20
Fine earth	99.10	99.80
Humus	.38	.97
Nitrogen	.0350	.0182
Moisture	.1860	.3300
Analysis of the Fine Earth:		
Insoluble residue	97.2280	97.7060
Potash (K_2O)	.0077	Trace
Soda (Na_2O)	.0067	.0278
Lime (CaO)	.0225	.0000
Magnesia (MgO)	.0144	.0063
Ferric Oxide (Fe_2O_3)	.0718	.1937
Alumina (Al_2O_3)		.2183
Phosphorus pentoxide (P_2O_5)	.0032	.0080
Chlorin	Trace	Trace
Sulphur trioxide (SO_3)	.0060	Trace
Carbon dioxide (CO_2)	.0000	.0000
Water and organic matter	2.7980	1.9500
Total	100.1583	100.1101

The following analysis is also taken from Bulletin 43 of the State Experiment Station. This sample was collected by C. W. Wilson, and was taken from near Lake Elbert in Polk County. The principal growth upon the land is small pine, with more or less oak. The sample represents the sandy rolling lands of the lake region:

Analysis of Virgin Rolling Pine Land, Soil and Sub-soil, of the Lake Region.

	Soil.	Sub-soil.
Coarse earth	8.83	7.16
Fine earth	91.17	92.84
Humus	.54	.17
Nitrogen	.0182	.0014
Moisture	.1800	.1000
Analysis of the Fine Earth:		
Insoluble residue	97.4560	98.3770
Potash (K_2O)	Trace	Trace
Soda (Na_2O)	.0234	.0344
Lime (CaO)	.0125	.0000
Magnesia (MgO)	.0261	.0117
Ferric Oxide (Fe_2O_3)	.4678	.3487
Alumina (Al_2O_3)		.1912
Phosphorus pentoxide (P_2O_5)	.0272	.0176
Chlorin	Trace	Trace
Sulphur trioxide (SO_3)	Trace	.0000
Carbon dioxide (CO_2)	.0000	.0000
Water and organic matter	2.0140	1.0194
Total	100.0270	100.0000

FLATWOODS.

The term "flatwoods" is applied to pine lands which are more level and consequently less well drained than the rolling pine lands.

PALMETTO FLATWOODS.

A widely prevailing type of country in parts of peninsular and west Florida is that which may be designated from its characteristic vegetation as palmetto flatwoods. The native timber growth is pine of several species, among which the long leaf or yellow pine, *Pinus palustris* predominates, although in the southern part of DeSoto County the species is replaced by the Cuban pine, *Pinus caribaea.* The characteristic undergrowth is wire grass and the saw palmetto (*Serenoa serrulata*). The palmetto flatwoods are in general level and sometimes so flat as to be more or less flooded during the rainy season. These overflows, however, are temporary, as the palmetto will not withstand excessive or prolonged flooding. The smaller streams are bordered by more or less swamp of hardwood growth. The larger streams as a rule are confined to definite channels in the palmetto flatwoods, have sandy banks and are not bordered by swamps other than the alluvial swamps of the rivers. Small circular depressions occupied by swamps of cypress or of hard wood trees are frequent in the palmetto flatwoods.

The soil is sandy and usually contains sufficient organic matter to give a gray or dark color. The palmetto flatwoods is very generally underlaid by a dark or chocolate colored stratum known as hardpan. The dark color is chiefly due, in the samples which have been analyzed, to organic matter. The coloring is most intense in the upper part of the stratum, and after passing one to three inches into the sand, the color grades to a chocolate or coffee grounds color, which in turn gives place at a variable depth to light colored sand. The hardpan stratum is the most characteristic and persistent feature of the palmetto flatwoods. The following analysis is of a sample of hardpan.

Analysis of a sample of hardpan from palmetto flatwoods; sample collected by R. M. Harper; analysis by A. M. Henry, assistant State Chemist:

	Per Cent.
Silica	95.62
Volatile or combustible matter	3.33
Undetermined (mostly clay)	1.05
Total	100.00

The most extensive areas of palmetto flatwoods lie bordering, or at least near the coast. It is not, however, confined entirely to the coast, but occurs inland where the conditions are favorable. Extensive areas of palmetto flatwoods are found interspersed with other types of soil through the greater part of peninsular Florida, except in the limestone section east of the Everglades in Southern Florida, where a distinct type of palmetto pine land is found. West of the Apalachicola River, aside from the strip bordering the Gulf coast, the palmetto flatwoods are not extensively developed. The pine trees on saw palmetto land rarely grow as large as on the other pine lands. This is due to the fact that the tap root is in many cases unable to penetrate the hardpan. Upon reaching this stratum the tap root frequently curls up or flattens out. This is illustrated by the accompanying photographs of trees growing on that type of land. Hardpan in the palmetto flatwoods is frequently found at a depth of 18 to 30 inches, although it may lie deeper, its occurrence and depth and thickness being controlled by the drainage conditions. During the dry season the hardpan becomes indurated and is said to interfere with the return of water to the surface by capillarity. In the case of irrigated lands this objection is overcome, and it is a notable fact that some of the very successfull trucking lands of the State are irrigated lands of this type, having a heavy growth of saw palmetto and sub-stratum of hardpan.

The Florida palmetto flatwoods resemble in some respects "Les Landes de Gascogne" in France, although the "Landes" were more marshy and less densely wooded, the pine trees being scattered in clumps or islands. Much of the land was open savanna and marsh. This area in France includes about three and one-half million acres and is underlaid throughout, according to Cobb*, by a substance there known as *alios,* apparently identical in character with the hardpan of the palmetto flatwoods of Florida. Reclus ascribes the origin of the *alios* to the infiltration of rain water which "carries into the ground various organic substances in a state of solution, and blends them intimately with arenaceous particles". (Cobb l. c.). In some localities under marshes in the "Landes", according to Cobb, the cementing substance of the *alios* is not organic but is iron oxide. This is doubtless true also in Florida, iron oxide and probably iron corbonate being in some instances the cementing substance. The "Landes" have been reclaimed by government drainage and are said to have been made both productive and healthful.

The hardpan of Florida, and the same is possibly true of the *alios* of the "Landes" of France, forms at the level at which the water table stands during the greater part of the year. Its formation is evidently due to the reaction in which organic acids take a part. Of these tannic acid, it may be safely assumed, is one, since although not confined to the flatwoods, hardpan is invariably associated in the flatwoods with the saw palmetto. Organic acids or tannic acid from other sources also take part in the reaction, since the hardpan is sometimes found underlying sections in which no saw palmetto grows. Thus in the sandhills of Leon County, hardpan has been found at a depth of about twenty feet, this being the ground water level at the locality. The surface vegetation in this locality includes a few stunted oaks and a sparse growth of wire grass.

Much of the land of the Florida flatwoods can be made available for farming by shallow ditching such as each farmer may make for himself at a nominal expense. However, there are large areas that would be benefited by more extensive systems of drainage. Such operations are now being carried on in different parts of the State either by communities or by private parties.

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*The Landes and Dunes of Gascony, by Collier Cobb. Journal of the Elisha Mitchell Scientific Society, Vol. XXVI, pp. 82-92, 1910.

The palmetto flatwoods are extensive and it is to be expected that several soil types are included and that these will be found to vary in both their chemical and mechanical constituents. Following is the analysis of a typical sample of the soil and sub-soil of the flatwoods taken by R. E. Rose in Osceola County. The chief vegetation growing upon the soil is pine, saw palmetto and wire grass. The analysis is from Bulletin 43 of the State Experiment Station, p. 666.

Analysis of Virgin Soil from Palmetto Flatwoods.

	Soil.	Sub-soil.
Coarse earth	1.10	.40
Fine earth	98.90	99.60
Humus	1.02	.38
Nitrogen	.0490	.0014
Moisture	.3800	.1500
Analysis of the Fine Earth:		
Insoluble residue	96.6970	98.7755
Potash (K_2O)	.0073	Trace
Soda (Na_2O)	.0438	.0172
Lime (CaO)	.0150	.0000
Magnesia (MgO)	.0252	.0054
Ferric Oxide (Fe_2O_3)	.0854	.2712
Alumina (Al_2O_3)		.1733
Phosphorus pentoxide (P_2O_5)	.0096	.0080
Chlorin	Trace	Trace
Sulphur trioxide (SO_3)	Trace	.0042
Carbon dioxide (CO_2)	.0000	.0000
Water and organic matter	3.1167	.8620
Total	100.0000	100.1168

The following is the analysis of a sample of the palmetto flatwoods near Punta Gorda in DeSoto County. From Bulletin 68 of the State Experiment Station, by H. K. Miller and H. H. Hume. The chief vegetation is Cuban pine and saw palmetto.

Analysis of Sample of Virgin Flatwoods.

	Soil.	Sub-soil.
Insoluble matter	98.9060	99.4696
Soluble silica	.0120	.0195
Lime	.0475	.0300
Magnesia	.0144	.0099
Potash	.0110	.0061
Iron and alumina	.0725	.0407
Phosphoric acid	.0050	.0068
Sulphur trioxide	.0068	.0051

Volatile matter	.9852	.4480
Humus	.4981	.2550
Nitrogen	.0250	.0090

Mechanical analysis of same, made by the Bureau of Soils, of the United States Department of Agriculture.

	Soil.		Sub-soil.	
Organic matter	1.16	per cent	.58	per cent
Gravel, 2 to 1 mm	.14	"	Trace	"
Coarse sand, 1 to .5	2.84	"	2.00	"
Medium sand, .5 to .25	6.72	"	6.02	"
Fine sand, .25 to .1 mm	73.50	"	75.02	"
Very fine sand, .1 to .05 mm	15.00	"	15.84	"
Silt, .05 to .005 mm	0.56	"	.32	"
Clay, .005 to .0001 mm	1.12	"	.30	"

OPEN FLATWOODS.

Another extensive type of country is that which may be designated as the open flatwoods or pine meadows. This type of country has practically no undergrowth other than the heavy mat of grass, chiefly wire-grass. The forest is chiefly the long leaf pine and slash pine. The streams through this type of country are flat bottomed and bordered by a dense swamp growth of hard wood trees of various kinds. The land is very level, so much so that drainage is imperfect and the land is more or less flooded during the summer rainy season. Ditching is necessary in order to drain the land for farming. The long leaf pine when cut off of this type of land reforests itself. The top soil is colored dark by the presence of organic matter. A few inches beneath the surface the soil becomes dark gray. A clay sub-soil may or may not be present and several varieties of soil may be distinguished, depending upon the texture of the soil, the sub-soil and the drainage conditions. Hardpan is not associated with this type of soil.

Large areas of soil of this type occur in both east and west Florida. In Nassau County a large area lying between the Seaboard Air Line Railway on the east and the Atlantic Coast Line on the west, reaching to the St. Marys River, is of this type. In Duval County a considerable area of this class of soil surrounds Baldwin, near the west line of the county. Along the St. Johns River areas of this type of soil occur at several places. In west Florida areas of this type are extensively developed. When cleared and sufficiently drained this type makes desirable farming and trucking land.

PINE LANDS OF THE MIAMI LIMESTONE.

A considerable area of country lying along the eastern border of the Everglades and extending from the Everglades to the Atlantic ocean is underlaid by limestone and supports a characteristic growth of Cuban pine and saw palmetto. The limestone is oolitic in character and lies very near the surface, being frequently exposed or covered only by a thin mantle of loose light-colored sand. The roots of the pine being unable to penetrate the rock, spread out horizontally along the surface, the pine on this land having no distinct tap root. This formation is of the Pleistocene age. It is probable that the thin soil is due to the relatively short time, geologically, that the surface has been exposed to the soil-forming processes.

The following analyses of samples of virgin rock soil from the Biscayne Bay, in Dade County, were made by A. A. Persons, and are published in Bulletin 43 of the Florida Experiment Station, pp. 653-655. The analyses were made in accordance with the methods adopted by the Association of Official Agricultural Chemists in 1895:

Analysis of Virgin Rocky Soil from Biscayne Bay.

	No. 1.		No. 2.	
	Surface.	Sub-soil.	Soil.	Sub-soil.
Coarse earth	7.20	7.40	2.60	7.00
Fine earth	92.80	92.60	97.40	93.00
Humus	2.77	.10	.23	.21
Nitrogen	.1666	.000	.0182	.0042
Moisture at 100 C.	1.2160	.0380	.1660	.1720
Analysis of the Fine Earth:				
Insoluble residue	87.7215	99.0850	98.0255	96.5225
Potash (K_2O)	.0043	.0024	.0178	Trace
Soda (Na_2O)	.0812	.0748	.0804	.1046
Lime (CaO)	.1275	.0425	.0725	Trace
Magnesia (MgO)	0612	.0108	.0351	.0387
Ferric oxide (Fe_2O_3)	.0278	.0914	.2044	.6519
Alumina (Al_2O_3)	.0682	.0162		1.0363
Phosphorus Pentoxide (P_2O_5)	.0240	.0224	.0256	.0268
Chlorin	Trace	Trace	Trace	.0483
Sulphur trioxide (SO_3)	.0103	.0086	.0086	.0103
Carbon dioxide (CO_2)	.0000	.0000	.0000	.0000
Water and organic matter	11.4600	.6620	1.5301	1.5606
Total	99.5860	100.0161	100.0000	100.0000

HAMMOCK LANDS.

The term hammock is applied to lands having a heavy growth of trees or shrubs among which usually the deciduous or hard-wood trees predominate, although a dense growth of pine is frequently classed as hammock. The hammocks include several distinct types of soil, and although not extensive in area, are important agriculturally.

CALCAREOUS HAMMOCK.

The calcareous hammock lands are underlaid at a depth not exceeding a few feet by some form of calcareous deposits, as marl, limestone, shell rock or shells. The native vegetation in the calcareous hammocks includes usually a variety of plants adapted to a calcareous soil. Among these are many hard-wood trees and shrubs, and where sufficiently moist the cabbage palmetto. The limestone, marl or shell, as the case may be, often lies practically at the surface or is covered by only a thin layer of soil. Such soils are fertile and lasting, and are well adapted to trucking crops.

Some extensive hammocks underlaid by limestone are found along the gulf coast in Hernando, Citrus, Levy, Lafayette, Taylor, Jefferson and Wakulla Counties. The hammocks in Wakulla and Jefferson Counties are underlaid by the Chattahoochee limestone The more extensive hammocks of Levy, Citrus and Hernando Counties are underlaid by the Vicksburg limestone. Hammocks resting upon the Vicksburg are found in the interior of the State in Alachua, Marion and Sumter Counties.

An extensive line of calcareous hammock land underlaid chiefly by shell marl and shell rock is found bordering the Atlantic coast almost continuously for a distance of some 200 miles. This east coast hammock rests chiefly upon and is caused by the coquina shell rock and marl. In the vicinity of Ormond, Daytona and New Smyrna this hammock belt reaches a width of from one to three miles. Another considerable development of the hammock is found a short distance north of Titusville. In these localities the hammock is known as Turnbull's hammock, being a part of the Turnbull grant made during the days of English rule. At Rockledge is seen another excellent development of the hammock belt immediately bordering the coast.

The Caloosahatchee River and some of its tributaries is bordered by calcareous hammock land, the formation giving rise to the hammock being the Caloosahatchee marl of Pliocene age. Many smaller calcareous hammocks occur throughout the State.

CLAY HAMMOCK LANDS.

Another distinctive type of hammock land is that which may be designated as the clay hammock lands, a clay sub-soil being frequently present. This type is due to the topography and is found only in rolling, well-drained or somewhat hilly sections, where the slope is sufficient to permit a partial removal of surface sands, thus permitting the addition of new soil from the underlying clays. The result is a strong and well-drained soil. The native vegetation includes hard wood trees of several varieties, among which are oak and hickory; the short leaf pine is also frequently found on this type of soil.

The largest areas of this type are the hammock lands of Leon, Jefferson, Madison and Jackson Counties. Holmes valley in Washington County, and Euchee valley in Walton County represent a similar hammock type due to similar causes. The Holmes valley hammock lies along the border line between the lowlands of Holmes creek and the elevated sandy plateau of the interior of the county. The surface wash along the foothills of this plateau is sufficient to remove the surface sand and to expose in places the underlying sandy clay, giving rise to a rolling hammock land with the usual hardwood and short leaf pine vegetation. Euchee valley represents the foothills encountered in passing from the lowlands of the Choctawhatchee River to the uplands of the interior of Walton County.

Orange Hill and Oak Hill in Washington County represent outliers from the plateau which now lies about three miles farther south. These two hills represent remnants of the plateau and illustrate the manner in which the plateau has receded southward from the more distinctly limestone country farther north.

SAND HILLS.

This type of country is rolling and distinctly sandy. The native growth is a sparse scattering of pine and a dense growth of scrub oak. There is a limited amount of organic matter in the soil, and the top soil may be bleached light colored, although a few inches beneath the surface the soil is usually light yellow in color. Although there are no surface streams the drainage of the sandhill country is good, as the rainfall passes at once into the sand. Hardpan was found in the sandhills at a depth of from twenty to twenty-five feet, this depth representing the water level in the locality.

THE SAND DUNES.

The sand dunes, recent and ancient, form by no means an unimportant type of country. These are found chiefly bordering the coast. Along the Atlantic coast sand dunes are found extensively. Near the northern line of the State at Fernandina the dunes border the coast, and are forming at present. Passing south, a line of ancient and quiescent dunes borders the coast lying from one-half to one and two miles inland, for a distance of 200 miles. When formed these dunes probably faced the coast, the land lying then at a lower level than at present. A subsequent slight elevation of the land having extended the coast line a short distance beyond the dunes. Since the elevation, which occurred probably at the close of the Pleistocene time, these dunes have become quiescent and are now overgrown by a dense growth of vegetation, consisting of spruce pine and shrubby plants. At the extreme southern end of the State. recent calcareous sand dunes occur. Along the gulf coast of Florida low quiescent sand dunes are found bordering the coast in Lee, DeSoto and Manatee Counties. From St. Petersburg along the gulf coast to Wakulla County the dunes are lacking. This coast is chiefly calcareous, representing that part of the coast line in which the Oligocene limestones border the coast. The western part of the gulf coast from Franklin to Escambia County is a section from which limestones are absent and sandy clay formations are exposed. Along this coast the sand dunes are again found more or less continuously. Those of the mainland are mostly quiescent. When originally accumulated the sand of the dunes was probably homogeneous, or nearly so. Subsequently under the weathering process a clear line of demarcation has been established between a top layer one to four feet in thickness and that which lies below. The top layer of sand is light colored or slightly gray near the surface from the accumulation of organic matter. At a depth of from one to four feet the color changes abruptly to pale yellow. This line of demarcation follows the contour of the hill in a cross section of the dune.

On the east border of Lake Kingsley in Clay County is found a series of dunes made up of white and unusually well-washed sands.

SCRUB.

The native vegetation of the "scrub" is more or less dense, and is often almost an impenetrable growth of shrubs or stunted trees of various kinds. The top soil is frequently light colored, although where the vegetation is dense, some organic matter accumulates. Passing beneath the surface the soil as a rule becomes ochre yellow.

Somewhat extensive areas of scrub lands are found in central peninsular Florida. It is frequently associated with, but not confined to, the lake region type of topography. The scrub is well-drained, since the rainfall passes at once into the sand. Sandy pine lands frequently give place to scrub without any apparent change in soil, topography or drainage conditions.

The present vegetation of the scrub has probably replaced an earlier growth of pine. This process of replacement of pine forests by the sand-loving species may be observed in many localities. The deciduous oaks are first to obtain a foothold among the pines. These in turn give place to the evergreen oaks, which seem to predominate in the scrub.

PRAIRIE AND SAVANNA.

The terms prairie and savanna are applied to lands that are level and devoid of trees or nearly so. The prairies as a rule are better drained than the savannas, although many of the prairies that are entirely dry during the dry season are more or less flooded during the season of summer rains. The soil of the different prairies is so variable as scarcely to admit of a generalized description. Clay soils and sandy soils are included as well as dark and light colored soils. Many of the prairies that are dry during a considerable part of the year have light sandy soils, the organic matter having been oxidized. Those prairies that are partly flooded retain proportionately more of the organic matter which gives the soil a dark color. A few of the large prairies or savannas were described in the Third Annual Report, pp. 43-76, 1910.

MARSH AND MUCK LANDS.

When land is overflowed during all or nearly all of the year, the growth of vegetation falls beneath the water, is protected from decay and accumulates to form muck. When drained the muck lands make fertile soils. The muck lands may or may not support a timber growth.

The term marsh is applied to overflowed lands devoid of timber but supporting a heavy growth of coarse grass. Marshes may be of salt or fresh water. The salt or marine marshes are found bordering the coast and have been built up by the tide. They consist largely of silt, mud and clay with an admixture of organic matter

The marine marshes being within the range of the tides, can be reclaimed only by diking, although if reclaimed they would undoubtedly prove very fertile. The fresh water marshes afford conditions favorable to the accumulation of vegetable matter and are frequently underlaid by deposits of muck.

The muck and fresh water marsh lands of Florida are extensive, aggregating not less than 5,000 square miles. The Everglades of southern Florida include the most extensive single area of muck lands, although many smaller areas occur throughout the State.

THE EVERGLADES.

The Everglades occupy the greater part of southern Florida. From Lake Okeechobee on the north they extend south to the Gulf of Mexico, a distance of 90 to 100 miles. Their maximum width is possibly 50 miles, although their average width is somewhat less. The boundaries, especially on the south and west, are more or less indefinite and irregular which makes it difficult to give a close estimate of their area. On the east they extend to within five to ten miles of the coast, their boundary being formed by a ridge of oolitic limestone rock, the Miami Limestone. Numerous streams originating in the 'Glades cut across this rim. Among these are Hillsboro River, New River, Miami River, Cypress Creek, and Snake River. To the south the boundary is less definite, as the 'Glades change character more or less approaching the Gulf, although in places the saw grass marsh reaches to the mangrove swamps bordering the coast. On the west side, the Everglades give place to cypress, prairie and pine lands. The total area of the Everglades is between 4,000 and 5,000 square miles.

The elevation of Lake Okeechobee at the head of the Everglades, has been determined by careful surveys. The level of the lake at the head of Okeechobee Canal was determind as 20.4 feet above mean low water in the Gulf of Mexico in 1901. Other levels made at various times indicate that the lake varies in level between high and low water stages from about 10 to 22½ or 23 feet. The Everglades which slope away from the lake toward the Atlantic and Gulf coasts receive the overflow from the lake.

The southern part of Florida was elevated above sea level during or at the close of the Pleistocene period. The Miami Limestone which underlies a part of the 'Glades and forms its east rim is, as previously stated, of Pleistocene age. On the west side of the 'Glades Pleistocene shell deposits are found at the head of the Caloosahatchee River. These formations, although of marine origin, are now found at an elevation of ten to twelve or more feet above sea level, indicating that during the Pleistocene the whole area of southern Florida was under water, but during or at the close of this period a slight elevation occurred which brought this part of the peninsula above water level. That this upward movement was general for southern and east Florida is indicated by the elevation of the coquina rock as far north as St. Augustine, and by the fact that marine shell deposits are found, as previously stated, at various localities along and near the east coast and in the St. Johns River valley. The beginning of the Everglades dates probably from this time.

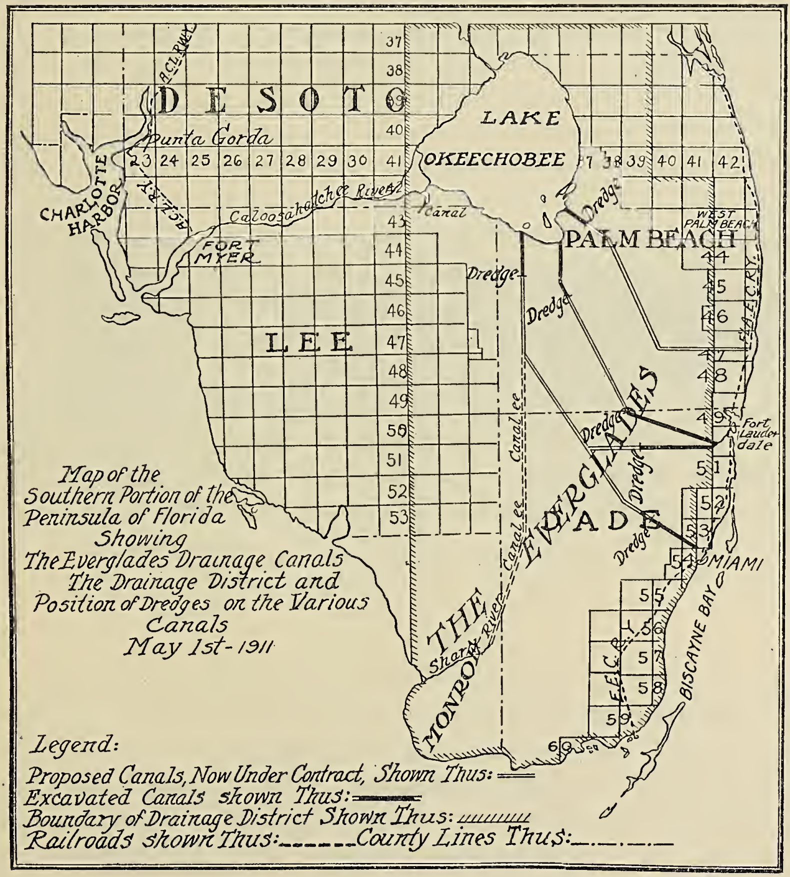
DESOTO
LAKE OKEECHOBEE
Punta Gorda
CHARLOTTE HARBOR
A.C.L. R'y.
Caloosahatchee River
Canal
FORT MYER
LEE
PALM BEACH
WEST PALM BEACH
Dredge
THE EVERGLADES
Canal
Fort Lauderdale
MIAMI
BISCAYNE BAY
F.E.C. R'Y.
THE MONROE
Shark River
Map of the Southern Portion of the Peninsula of Florida Showing The Everglades Drainage Canals The Drainage District and Position of Dredges on the Various Canals May 1st-1911
Legend:
Proposed Canals, Now Under Contract, Shown Thus:
Excavated Canals shown Thus:
Boundary of Drainage District Shown Thus:
Railroads shown Thus:
County Lines Thus:

Fig. 2.—Sketch map of southern Florida showing progress in drainage of the Everglades to May, 1911.

The basin of Lake Okeechobee represents probably a natural depression which existed at the time of the uplift. According to the sounding made by Wright, this basin, now a lake, has an average depth of about 12 feet, and a maximum depth of 22 feet. When first elevated such basins contain salt water which subsequently becomes fresh by the influx of water from the surrounding drainage basin.

The unusually level character of the country, the heavy rainfall, and the overflow from Lake Okeechobee have resulted in the formation of the marshy conditions and the accumulation of the muck deposits which now characterize the Everglades. The process has been a slow accumulation of muck which is now found to a depth of 5 to 12 feet, depending upon the natural irregularities of the surface. The length of time involved in the accumulation of this muck is difficult to estimate. A crude measure of the time that has elapsed since the earth movements that brought this part of the State above sea level and originated the conditions which produced the Everglades is found in the amount of cutting that has been done by the several streams draining from the 'Glades. The Miami River has cut back from the coast, partly by mechanical wear and partly by solution, a distance of about six miles. The waterfall at the head of this river has now been cut out by the dredging operations. The other streams have cut channels proportionate to the volume of water modified by the character and hardness of the formations through which they are cutting.

An extensive plan for the drainage of the Everglades has been made and is being carried out under the direction of the Drainage Commission of the State. Aside from the Everglades, many smaller tracts of muck, prairie, and other wet lands in Florida are being drained, either by private enterprise or by communities under special legislative act providing for drainage districts.

ALLUVIAL LANDS.

The alluvial lands of Florida have been but little used for agriculture. Many of the streams and rivers have flat bottomed valleys densely wooded with hardwood trees. Within these valleys the streams are often confined to no definite channel. During the summer, owing to the heavy rains, together with the impeded flow through the trees, the valleys are as a rule flooded. In many of these the streams could be confined to a central channel and a considerable part of the valley made available for agricultural purposes by clearing out the dense growth of trees. However, the expense of clearing land of this kind is considerable, and notwithstanding its fertility, very little of it as yet has been reclaimed.

The alluvial valley of the Apalachicola River has a width of one to two miles. It has a rich sandy soil, but is flooded at the high stages of the river and has been but little used. The native vegetation is a dense growth of hardwood timber. The Apalachicola, unlike the other rivers of Florida, receives its head waters from the Apalachian Mountains, and is less affected by the rainy season of Florida than by the melting of the snows of the mountains.

Those streams which flow through limestone country carry little or no sediments in suspension. Their channel is cut chiefly by solution. Such streams have sandy banks and little or no alluvial lands.

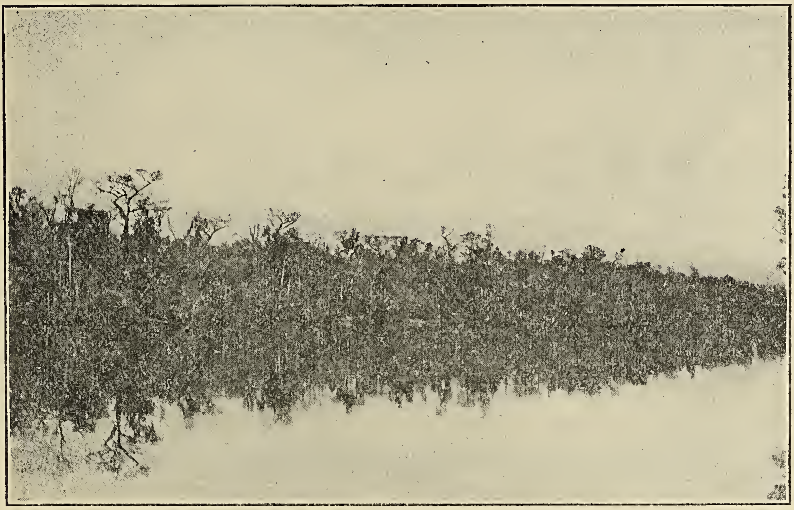

Fig. 3.—Swamp of St. Marys River.

SWAMP LANDS.

The term swamp is applied to overflowed lands supporting a growth of trees. The swamps of Florida were described and classified in the preceding report of the Survey. It is probable that the total swamp area of the State aggregates not less than 3,000 square miles, much of which is capable of being drained and utilized.

THE UNDERGROUND WATER SUPPLY OF WEST-CENTRAL AND WEST FLORIDA

BY E. H. SELLARDS AND HERMAN GUNTER.

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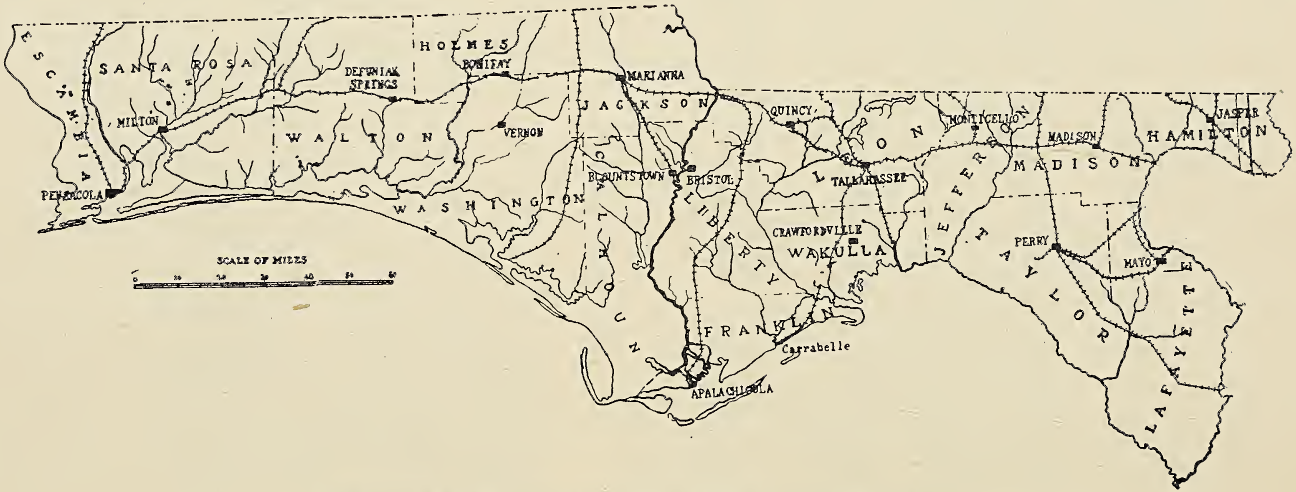

Fig. 4.—Map of Florida west of the Suwannee River.

THE UNDERGROUND WATER SUPPLY OF WEST-CENTRAL AND WEST FLORIDA.

E. H. SELLARDS AND HERMAN GUNTER.

INTRODUCTION.

The following is the third of a series of papers on the water supply of the State. The first of these was published in 1908 as Bulletin No. 1 and relates to the water supply of eleven counties in central Florida as follows: Alachua, Columbia, Citrus, Hamilton, Hernando, Lake, Levy, Marion, Pasco, Sumter, and Suwannee. The second paper on water supply was published in the Third Annual Report, pages 77 to 195, 1910, and included nine counties in eastern Florida as follows: Brevard, Clay, Duval, Nassau, Orange, Putnam, St. Johns, St. Lucie, and Volusia. This paper, the third of the series, includes a report on the water supply of sixteen counties lying west of the Suwannee River as follows: Calhoun, Escambia, Franklin, Gadsden, Holmes, Jackson, Jefferson, Lafayette, Leon, Liberty, Madison, Santa Rosa, Taylor, Wakulla, Walton, and Washington.

Acknowledgement is due in this as in former papers to the many well drillers, well owners and others who have contributed notes and records and otherwise assisted in collecting data.

LOCATION.

The area included in this report lies bordering the Gulf of Mexico from the Perdido to the Suwannee River, and has 500 miles of coast line. Along this coast are a number of excellent harbors among which may be mentioned Pensacola Harbor, Choctawhatchee Bay, St. Andrews Bay, St. Joseph Bay and other smaller harbors. In width the area varies from 40 to 100 miles. The area is included chiefly between latitude 30 and 31 degrees, and between longitude 83 and 88 degrees.

CLIMATE.

The records of temperature and rainfall are available from the report of the United States Weather Bureau at the following three stations within the area covered by this paper, Pensacola, DeFuniak Springs and Tallahassee.

The averages for both rainfall and temperature at Pensacola are based on the records at this station from 1879 to 1903. The averages for rainfall and temperature at DeFuniak Springs are obtained from the records from 1896 to 1903. The averages for rainfall and temperature at Tallahassee are based on records from 1891 to 1903.*

TEMPERATURE.

Pensacola is located on the Gulf of Mexico near the west line of the State. The mean annual temperature at Pensacola is 68 degrees Fahrenheit. The mean temperature for the four seasons of the year are as follows: Winter 54 F.; Spring 67 F.; Summer 81 F.; Fall 69 F. The absolute maximum of summer heat recorded at Pensacola is 103.

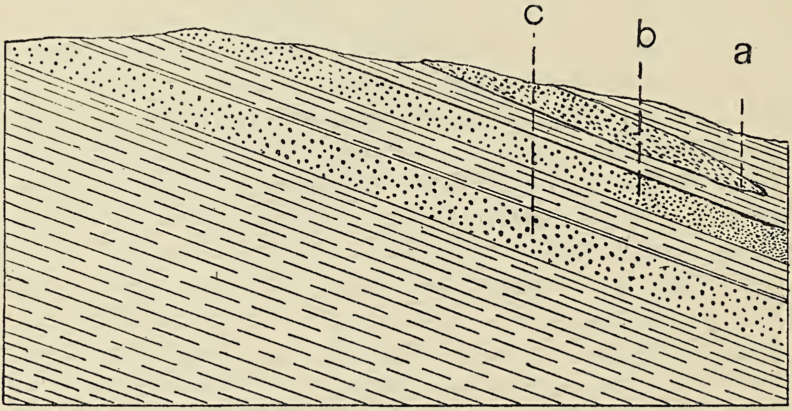

Fig. 5.—Illustrating structures that may prevail in an artesian slope; a. a previous water-bearing stratum which pinches out between impervious strata; b. a pervious water-bearing stratum which grades into a less pervious stratum; c. a pervious water-bearing stratum in which the artesian pressure is due merely to the friction of water moving through the pores of the rock.

At DeFuniak Springs in Walton County the mean annual temperature is 67 degrees Fahrenheit. The mean temperature for the four seasons of the year is as follows: Winter 51; Spring 67; Summer 81; Fall 68. The absolute maximum summer heat recorded at this station is 105.

At Tallahassee in Leon County the mean annual temperature is 67 degrees Fahrenheit. The mean for the four seasons of the year is as follows: Winter 53; Spring 67; Summer 80; Fall 68. The absolute maximum summer heat recorded at this station is 97.

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*Climatology of the United States, by Alfred Judson Henry, Bull. Q. U. S. Dept. Agriculture.

RAINFALL.

The annual mean rainfall at Pensacola is 56.8 inches. This is distributed throughout the year as follows: January, 4 inches; February, 4.6 inches; March, 5.7 inches; April, 3.2 inches; May, 2.9 inches; June, 5.2 inches; July, 6.7 inches; August, 7.9 inches; September, 4.8 inches; October, 3.8 inches; November, 4. inches; December, 4 inches.

The annual mean at DeFuniak Springs is 67.8 inches, distributed throughout the year as follows: January 3.4 inches; February 8.4 inches; March 7.7 inches; April 2.7 inches; May 3.8 inches; June 6.4 inches; July 7.3 inches; August 11.2 inches; September 4.8 inches; October 3.6 inches; November 4.4 inches; December 4.1 inches.

The annual mean rainfall at Tallahassee is 58.2 inches. This is distributed throughout the year as follows: January 3.5 inches; February 4.8 inches; March 5.9 inches; April 2.7 inches; May 3.6 inches; June 6.8 inches; July 8 inches; August 7.1 inches; September 5.1 inches; October 3.7 inches; November 2.9 inches; December 4.1 inches.

ARTESIAN WATER SUPPLY.

The artesian water supply is one of the very important assets of Western Florida, and the area in which flowing artesian wells can be obtained is shown on the maps which accompany the reports on the several counties. The geological structure of Western Florida is favorable for artesian water especially along the coast. The formations as a rule slope toward the coast in a manner illustrated in a general way by the accompanying cut (Fig. 5). Under these conditions water accumulates under pressure resulting in a flow when the water-bearing stratum is reached by the drill. The principles which control underground water supplies as well as the geologic structure of Western Florida have been more fully discussed in the previous reports.

Artesian wells may be classed as flowing and non-flowing. The flowing wells are those in which the water rises to and above the surface, and hence flows. The non-flowing wells are those in which the water is under pressure and rises in the bore hole when reached by the drill, but does not reach the surface. The difference between flowing and non-flowing wells is in many cases merely a difference in surface elevation.

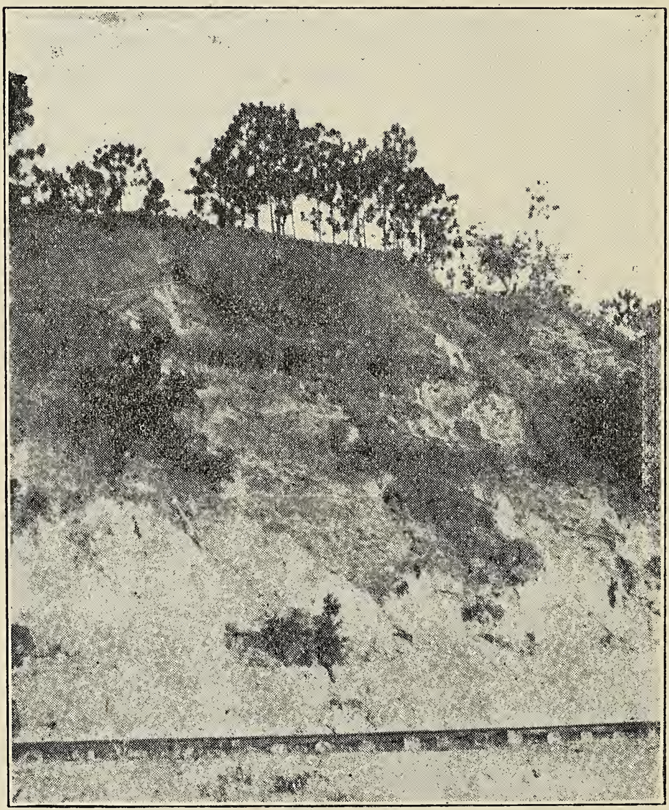

Fig. 6.—Bluff facing Escambia Bay, Escambia County.

COUNTY REPORTS.

In the following reports the counties are taken in order from west to east. A map showing the location of the counties will be found on page 86.

ESCAMBIA COUNTY.

LOCATION AND SURFACE FEATURES.

Escambia the westernmost county in the State is separated on the west from Baldwin County, Alabama, by the Perdido River. It extends from the Alabama state line on the north to the Gulf of Mexico on the south. On the east the Escambia River divides it from Santa Rosa County. The area is 668 square miles or 427,520 acres.

The surface features of the county fall into two more or less distinct divisions. For a distance of about 10 miles from the Gulf of Mexico north the country is comparatively level and sandy with but few surface streams. The principal growth on this sandy soil is scrub oak and long leaf pine. Most of the pine has been cut away and but little second growth has replaced it. The second division embraces the northern portion of the county which is characterized by a gently undulating to rolling topography, becoming somewhat broken as the rivers and larger streams are approached. This section supports a vigorous growth of long leaf pine. The soil, generally speaking, is a heavy red to yellowish sandy clay covered with a mantle of sand of greater or less thickness. Streams are numerous affording in several instances water transportation for the products of the many lumber mills in this part of the county. Seepage springs afford also a good supply of soft water for domestic purposes and often the waters from these springs are dammed up and used for manufacturing supplies. The presence of such an abundant supply of water from these springs and the ease with which surface water wells are obtained have thus far obviated to a great extent the necessity of deep well drilling. Surface water wells are obtained at depths varying from 16 to 60 or more feet depending upon local surface variations.

The geology of Escambia County presents many difficulties and has not been described in detail. Chief among the difficulties is the absence of fossiliferous horizons from which the age of the formations may be determined. The surface formations throughout the county consist of sandy clays, which upon disintegration form the superficial sands. The age and correlation of these sandy clays has long been a question and is likely to remain so until fossil-bearing horizons are discovered or until very detailed stratigraphic studies are made showing unmistakably the relation of the clay to other known formations. By some the superficial sands are referred to the Columbia formation. But this lacks confirmation, as the loose sands are evidently formed through the disintegration of the underlying sandy clays.

The record of the underlying formations is likewise very incomplete. The drillings pass through alternate layers of sands and sandy clays. Occasional shell marls are reported, but no limestone or other hard rock, has been encountered. In the well of the Southern States Lumber Company midway between Muscogee and Cantonment, Miocene shells were identified from a sample 500 feet from the surface. The well of W. F. and S. Lee, 4½ miles west of Pensacola terminated at the depth of 1,000 feet in coarse sands.

A discussion of the soils of Escambia County is much facilitated by the fact that a detailed soil map of this county has been made by the Bureau of Soils of the United States Department of Agriculture. Aside from the river swamps the marshes and the coastal beach sands three prominent soil series are recognized, known as the Portsmouth, Norfolk and Orangeburg, and a fourth series, the Myatt, is sparingly represented along the valleys and in the heads of some of the streams.

The Portsmouth series includes soils which are poorly drained, and contain in consequence a relatively large amount of organic matter. Perfect drainage, with exposure to sunlight, results, as is well known in oxidizing the organic matter in soils. On the other hand soils flooded or saturated with water retain the organic matter, giving the soil a dark color. A considerable area of this latter type of country is found in the southwestern extension of the county bordering the Perdido Bay. This section of the county is low, being only a few feet above sea and traversed by many bay heads. The soil is sandy and is colored dark by organic matter. The native vegetation is pine. Much of this land is capable of being reclaimed by ditching. Flowing artesian wells can be obtained along this bay, and the land when reclaimed and irrigated should be valuable for the production of truck and general crops.

The Norfolk series includes, in contrast to the Portsmouth, light sandy well drained soils. The extreme members of this series consist of sand to an undetermined depth with little or no distinction between soil and sub-soil, or with scarcely an appreciable change from the light colored top soils to ochre red sub-soils. Other members of the soils of this series grade from light sandy top soils to ochre yellow clay sub-soils. The largest continuous area of Norfolk soils in Escambia County lies immediately north of Pensacola, and extends a distance of about ten miles from the Gulf. This section is level or gently rolling, although from its elevation of from 50 to 100 feet above sea it is well drained. The drainage, however, is not by surface streams, of which there are very few and these quite immature, but by seepage, the rain water passing through the top soil and into the underlying sandy clays. The rain water in passing through the soils has removed the clay particles to a lower depth, *and has dissolved and removed the iron stain from the sands. In this way there has been formed over this area a light colored sandy soil. The timber growth is chiefly long leaf pine, which when cut down is replaced by scrubby oaks.

The remainder of the county lying to the north of this section and including the greater part of the county, has much more diversified soils. The Norfolk sandy soils are present locally, although types of the Norfolk having a clay sub-soil predominate. This is the part of the county in which the surface drainage system is well developed, and the country rolling. There are found also soils of the Orangeburg series. This series differs from the Norfolk series chiefly in that the sub-soil is red instead of yellow. The Orangeburg soils are found locally over all this northern section of the county. These soils support an excellent growth of long leaf pine, and lumbering has been the chief industry in the past with but little attention being paid to the agricultural possibilities. Most of these soils are naturally productive and are well adapted to general farming.

Tree swamps, as previously stated, border the streams the broadest swamp being that which borders the Escambia River. Coastal beach and wind blown sands occur bordering the coast.

ELEVATIONS.

Commencing with sea level at Pensacola the surface elevation rises gradually until at Cantonment, a station on the branch of

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*The formation of residual sands is more fully discussed in the preceding paper on soils, pages 19 to 27. To the citations on page 22 of that paper should be added Bulletin 26, Georgia Geol. Surv., preliminary report on the Geology of the Coastal Plains of Georgia by Otto Veatch and L. W. Stephenson. This report, by Veatch and Stephenson, although printed in 1911, was not received until February, 1912, and after the paper on soils had been printed. A mineralogical examination of a sample of sandy sub-soil from Escambia County is given in Bull. 79, U. S. Dept. Agriculture, p. 26, 1911. The minerals recognized include, quartz, rutile, zircon, orthoclase, and traces of tourmaline.

the Louisville and Nashville Railroad leading north from Pensacola and connecting with the main line at Flomaton, Alabama, an elevation of 180 feet is reached. Other recorded elevations along this line of railroad are as follows: Gonzalez 170 feet; Quintette 120 feet; Molino 58 feet; Pine Barren 57 feet; McDavid 74 feet; Bluff Springs 90 feet; Flomaton, Alabama, 100 feet.* Molino, Pine Barren, McDavid and Bluff Springs are located either in the valley of or in close proximity to Escambia River which accounts for their lower elevation. Leaving the lowlands of the rivers and streams the rolling uplands immediately begin. Elevations of points in the middle and western portions of the county unfortunately are lacking.

DRAINAGE.

The drainage conditions of Escambia county are good. The Escambia River borders the county on the east and the Perdido River on the west. The tributaries of these two rivers afford drainage for the greater part of the county.

AREA OF ARTESIAN FLOW IN ESCAMBIA COUNTY.

The flowing area of Escambia county includes a considerable area bordering the Gulf of Mexico on the south and bordering each of the two rivers defining the county boundaries, the Escambia on the east and the Perdido on the west. An artesian flow can also in all probability be obtained along the many tributary streams which traverse this part of the county and in other sections where the elevation is relatively low. The northernmost flowing well on the eastern border of the county is at McDavid about ten miles from the northern boundary line. This well is 74 feet deep and terminates in a coarse sand stratum. The elevation at McDavid is 74 feet above sea according to the records of the Louisville and Nashville Railroad. The well furnishes a good flow of water rising from 8 to 10 feet above the surface. On the western side of the county records of flowing wells have been obtained as far north as Muscogee. The head of the water here is reported to be about 40 feet above the surface. The shaded lines on the map on page 95 indicate the area of artesian flow in this county.

The artesian water of Escambia county coming as it does chiefly from sand and sandstone formations is as a rule a soft or "freestone" water. In fact some of the softest artesian waters in the State are from this and other counties of west Florida.

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*Dictionary of Altitudes, Bull. 274, U. S. Geol. Surv. pp. 185-194, 1906.

LOCAL DETAILS.

BOHEMIA.

Bohemia is located in the southeast portion of the county on the Louisville and Nashville Railroad at the base of the bluffs facing Escambia Bay. Four two-inch wells have been sunk here and flowing water was obtained at the depths of 52 and 56 feet. The wells are owned by the Home Mill Company and were sunk in 1907 and 1910. A good flow of soft chalybeate water is obtained having a head of three or more feet above the surface. Driven surface water wells are obtained at depths of from 18 to 26 feet.

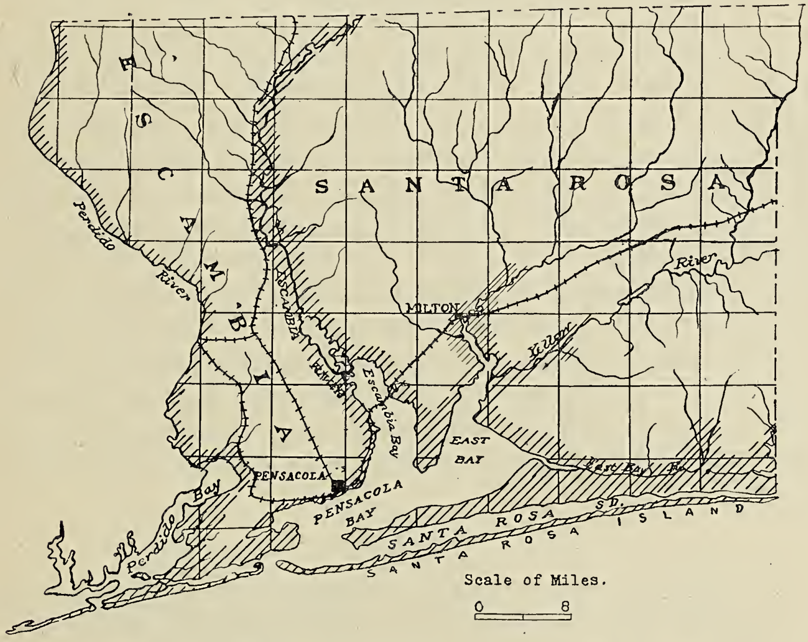

Fig. 7.—Map showing the areas of artesian flow in Escambia and Santa Rosa Counties. The areas in which flowing wells can be obtained are indicated by shading.

CANTONMENT.

The deepest boring in the county of which record has been obtained is a well drilled for oil in 1905 by Messrs. Sutter and LeGallais for the Southern States Lumber Company about 3 miles west of Cantonment. At the depth of 1452 feet the boring was discontinued and the well abandoned. The drillers report a dry hole with the exception of one water-bearing stratum in which the water stood about 40 feet below the surface. A complete log and some samples of the materials penetrated were furnished the United States Geological Survey and the results of an examination of the fossils found in the drilling are incorporated in the Second Annual Report of this Survey, pages 117 and 118. Fossil shells from three different depths, 500, 670, and 890 feet, respectively, are reported upon but unfortunately the samples became mixed and the only importance to be attached to their identification is that marls of Miocene age are represented. The general water supply for domestic use in and around Cantonment is from wells ranging from 40 to 60 or more feet in depth terminating in sands and sandy clays.

MOLINO.

An artesian well was drilled for H. C. Jacobi at Molino in 1908 by F. J. White. This well reaches a depth of 475 feet, and the first flowing water was obtained at 426 feet. The water is soft and rises fifteen feet above the surface. In the process of drilling the size of the casing was reduced from four to three inches in diameter. The well contains 400 feet of four-inch casing and 475 feet of three-inch casing. It is worthy of mention that at Pine Barren about 4½ miles north of Molino a flow with greater pressure than that at Molino is obtained at the comparatively shallow depth of not more than 150 feet. The elevation at Molino is practically the same as at Pine Barren. The extreme variableness of the water-bearing sands and gravels that yield the artesian waters in this section is evident from the difference in the records of the two wells.

MUSCOGEE.

The Southern States Lumber Company own one artesian well at Muscogee which is 180 feet deep. This well is 2½ inches in diameter and is cased to the bottom. It is reported to have a head of 40 feet above the surface. The water has a slight sulphur odor and is said to form some scale in the boilers. Another well which was owned by this company was abandoned on account of the injurious effect the water had on boilers. The principal water supply for general use around the mill is obtained from shallow driven wells varying from 16 to 26 feet in depth. The water from these wells does not flow but rises to within a few feet of the surface and is more strongly impregnated with sulphur than is the water from the deeper well. The following analysis of the water from the 180 foot well was kindly supplied by Mr. W. R. Vaughn, Superintendent of the Southern States Lumber Company. The analysis was made in 1908 by Mr. Stephen Lee, at that time a student in the University of Mississippi.

Constituents.	Parts per Million.
Silica (SiO_2)	55.18
Sodium Chloride ($NaCl$)	19.77
Sodium Sulphate ($NaSO_4$)	3.30
Sodium Carbonate ($NaCO_3$)	6.05
Magnesium Carbonate ($MgCO_3$)	11.14
Calcium Carbonate ($CaCO_3$)	2.10
Iron and Aluminum Oxides	5.40
Potassium Sulphate (KSO_4)	12.74

PINE BARREN.

The first artesian well at Pine Barren was sunk about 1891 by Mr. W. J. Malone, of Brewton, Alabama, for the McMillan Mill Company. Since that time three additional wells have been drilled for this company by Mr. Malone, the last one being completed in 1909. These all average 150 feet in depth and range from 1¼ to 1½ inches in diameter. They yield a flow of about 40 gallons per minute of good soft water which is used for general purposes around the mill. The reported pressure of these wells is 15 pounds to the square inch which is pressure sufficient to cause the water to rise 34.65 feet above the surface. The elevation of the depot at this place as recorded by the Louisville and Nashville Railroad is 57 feet. This elevation, which is approximately the same as that of the well near the depot, will give for these wells a total head of about 91.65 feet above sea. The following analysis showing the character of this water was made for the State Survey in the office of the State Chemist, A. M. Henry, Analyst.

Constituents.	Parts per Million.
Silica (SiO_2)	16.8
Sulphates (SO_4)	8.1
Bicarbonates (HCO_3)	40.4
Carbonates (CO_3)	0.0
Nitrates (NO_3)	0.005
Iron & Aluminum Oxides (Fe_2O_3&Al_2O_3)	1.1
Calcium (Ca)	7.7
Magnesium (Mg)	1.5
Potassium (K)	2.6
Sodium (Na)	10.8
Total	100.205

The probable combination of the constituents is as follows:

Sodium Chloride ($NaCl$)	15.9
Sodium Sulphate (Na_2SO_4)	12.0
Sodium Bicarbonate ($NaHCO_3$)	7.6
Potassium Bicarbonate ($KHCO_3$)	6.7
Calcium Bicarbonate ($Ca(HCO_3)_2$	31.1
Magnesium Bicarbonate ($Mg(HCO_3)_2$	9.0

McDAVID.

A well for the town of McDavid was sunk in 1910 by Mr. R. B. Bell. This is the northernmost flowing well in the county being only about 10 miles from the northern boundary. The total depth is 74 feet and a good flow of soft water rising about 10 feet above the surface is obtained. The depot at McDavid according to elevations by the Louisville and Nashville Railroad is 74 feet above sea. This town well is only a short distance from the depot and has about the same elevation, thus giving it a head of approximately 84 feet above sea. Another flowing well at this place is the one owned by the Mayo Lumber Company which was sunk by Mr. Bell in 1909. This well reaches a depth of 143 feet and furnishes a good flow of soft water, which is reported to come from a formation of gravel as was also the case in the well listed above. A third well sunk by Mr. Bell in this neighborhood is that of Mr. W. E. Tompkins which is 130 feet deep and is non-flowing. The water is reported to stand 30 feet below the surface. The elevation here is considerably more than at the depot which probably accounts for the water not rising above the surface. The general water supply for McDavid and vicinity is from wells 40 to 60 or more feet in depth terminating in the underlying sands and sandy clays.

PENSACOLA.

The range of the depth of the artesian wells in and around Pensacola is from 130 to 200 feet. Wells of this depth near the bay shore obtain a flow while the water in those located on higher ground rises to within a few feet of the surface. A great number of wells are found here, but as all have similar records only a few will be mentioned. The city of Pensacola is supplied with water from 16 wells averaging 130 feet in depth and ranging from 4 to 6 inches in diameter. The first of these was sunk in 1886. The water in these wells stands 16 feet below the surface. It is said that no decrease in the supply has been noticed, although on account of increased consumption of water, which is now (March, 1911) 1,200,000 gallons daily, additional wells have had to be added from time to time. The water from these wells is an excellent soft water with a slight taste of iron. The following four analyses of water representing the city water supply were made by Dr. George A. Roper, of New York City, and were reported September 26, 1902. At the time these analyses were made the water system was owned by the Pensacola Water Company. The system is now operated by the city.

Constituents.	Parts per Million.			
	1	2	3	4
Turbidity	very slight	very slight	very slight	very slight
Color	very slight	very slight	very slight	very slight
Odor (Hot)	none	none	none	none
Odor (Cold)	none	none	none	none
Residue on evaporation	22.0	35.0	35.0	24.0
Albuminoid ammonia	.006	none	none	none
Free ammonia	.000	none	none	none
Nitrites	.000	.002	.002	.002
Nitrates	.000	none	.000	.000
Chlorine	4.8	4.8	4.8	3.6
Iron	.35	.02	.02	.2
Hardness	.00	.0	.0	.0
Alkalinity	.00	.0	.0	0.

Number 1 is anaylsis of water collected from a faucet in the office of the Southern Express Company, representing water of 10 wells varying in depth from 120 to 130 feet. Number 2 is water from a group of wells at the pumping station of the Pensacola Water Company collected September 13, 1902. Number 3 is also from a group of wells of the Pensacola Water Company and collected September 13, 1902. Number 4 is water from a well of Pensacola Water Company in Gonzalez Street collected September 14, 1902.

The many wells owned by the different ice companies, manufacturing concerns and private individuals vary in depth from 125 to 195 or more feet. In the drilling of all of these that have been recorded no great difficulty in boring is experienced. The drillers report for the most part a series of sands, sandy clays and gravels. No hard rock or boulders were reported and the only rock of which any mention was made was a ferruginous sandstone. This is irregular and lies at a variable depth from the surface. The water from these wells is soft and is excellent for all manufacturing purposes and domestic uses.

The deepest well near Pensacola is the one owned by Messrs. W. F. and Stephen Lee. This well, known as Vichy Springs, is about 4½ miles south west of Pensacola on Bayou Grande sometimes called Big Bayou. It is 1011 feet deep, four and one-half inches in diameter and is cased to the bottom. The last 150 feet of the bore-hole was reduced to three inches in diameter. The well is said to have a flow of 150 gallons per minute and to have a pressure of 24 pounds to the square inch which is sufficient pressure to cause the water to rise 55.44 feet above the surface or about 65.44 feet above sea. The temperature of the water is given as 92° Fahrenheit. The water is bottled and sold as a medicinal water, The following is an analysis of the water from this well. Analysis for the State Survey in the office of the State Chemist, A. M. Henry, analyst.

Constituents.	Mligrams per liter or approximately parts per million.
Silica (SiO_2)	37.6
Sulphates (SO_4)	7.6
Bicarbonates (HCO_3)	623.0
Carbonates (CO_3)	0.0
Nitrates (NO_3)	0.57
Chlorine (Cl)	1691.5
Iron and Aluminum Oxides (Fe_2O_3 and Al_2O_3)	2.0
Calcium (Ca)	10.4
Magnesium (Mg)	5.1
Potassium (K)	13.1
Sodium (Na)	1307.0
Total	3697.87

The probable combination of the above is as follows:

Sodium Chloride (NaCl)	2791.5
Sodium Sulphate (Na_2SO_4)	11.2
Sodium Bicarbonate ($NaHCO_3$)	754.7
Potassium Bicarbonate ($KHCO_3$)	33.5
Calcium Bicarbonate ($CaHCO_3)_2$	40.1
Magnesium Bicarbonate ($Mg(HCO_3)_2$	30.2

Near this deep well is a shallow well. This is six inches in diameter and reaches a total depth of 155 feet being cased the entire depth. The water which is soft and fresh comes to within three feet of the surface.

The United States Government has sunk wells at Fort Pickens, Fort Barrancas and Fort McRee which furnish the general water supply for the forts mentioned. The following information regarding these wells was kindly supplied by the War Department, office of the Chief of Engineers, Washington, D. C.

At Fort Barrancas two six inch wells have been drilled, depths 278 feet and 370 feet. The water does not flow but is pumped by force with air compression. The well is located on ground 28 feet above sea level. An analysis of this water made in the chemical laboratory of the War Department and reported May 13, 1905, by Edwin R. Hodge, Chemist in charge, showed it to contain 13.50 parts chlorine and 70.50 parts total solids per million parts water.

At Fort Pickens four wells have been drilled varying in size and in depth as follows: one well 310 feet deep, six inches in diameter; one well 315 feet deep, six inches in diameter; one well 310 feet deep and four inches in diameter; and one well 300 feet deep and two and one-half inches in diameter. The water from these wells does not flow but is pumped by suction. A combined sample of the water from these four wells was analyzed and reported February 11, 1908, in the chemical laboratory of the War Department and was found to contain 66.50 parts chlorine and 315.00 parts total solids per million parts water. This water shows a decidedly heavier mineral content than the wells at Fort Barrancas.

At Fort McRee one six-inch well has been drilled to a depth of 384 feet or deeper than any of the wells above recorded. This well flowed, July 9, 1910, four gallons per minute. An analysis of the water from this well reported by Edwin R. Hodge shows the chlorine content to be 160.00 parts and the total solids 483.50 parts to a million parts water.

SANTA ROSA COUNTY.

LOCATION AND SURFACE FEATURES.

Santa Rosa County lies next east of Escambia County, the Escambia River forming the boundary line. To the north the county extends to the Alabama-Florida line, while on the east the Yellow River together with the western boundary of Walton county forms its eastern limits. To the south it reaches to the Gulf of Mexico. The total area is 1528 square miles, or 977, 920 acres.

The topography of the county is for the most part gently rolling although there are large portions in the southern half which are almost level. The rolling area, comprising the northern half of the county, is timbered principally with an excellent growth of long-leaf pine. Different species of oaks are seen and cypress, together with juniper, is also quite plentiful along the stream valleys. The drainage in this region is as a rule excellent since the streams are numerous, however, there are large tracts of unbroken country lying between the different streams a little above the general surrounding territory which are very level and during the season of heavy rainfall may be insufficiently drained. That this feature is not of serious consequence is evidenced by the fact that this belt embraces some of the largest and most successful farms in the county, and includes the greatest continuous area now under cultivation. Toward the north line of the county and approaching the streams the country becomes a little hilly but not to the extent of making it undesirable for agricultural purposes.

This county may be divided into two more or less distinct physiographic divisions, which include different types of soils. The southern part of the county presents a level sandy region which has a gradual slope to the Gulf of Mexico. The timber growth is chiefly the black-jack oak and the long leaf pine. The sand is of considerable depth and the soil is but little used for agricultural purposes at the present time. There are few streams and creeks but the drainage is good as the rainfall passes directly into the loose porous sands.

That part of the county lying to the north includes the heavier and loamy types of soils. The principal growth is the long leaf pine, although along the streams and other low and wet places cypress, juniper, black gum, sweet gum, and other trees are abundant. The saw palmetto which is so common in some other parts of the State is rare in this section. The central part, lying between Coldwater Creek and Pond Creek, is very level and the soil here is sandy with a red to yellowish sandy clay sub-soil varying from a few inches to one foot or so below the surface. This is a good farming section as evidenced by the many large and well kept farms now under cultivation. The northwestern boundary of the county is said to be of a little more rolling and clayey nature, the clay being to a great extent exposed on the surface. This is also reported to be one of the desirable farming sections of the county.

ELEVATIONS.

The following elevations are based on surveys made by the Louisville and Nashville Railroad as reported in Bulletin 274 of the United States Geological Survey. Crestview in Walton County, near the western boundary line of Santa Rosa County, is 175 feet above sea level. From Crestview to Holt, a distance of about 12 miles, the elevation rises to 212 feet. This is the highest recorded point in the county. Good Range is 164 feet and Milton, which is on Blackwater River, has an elevation of only 15 feet above sea.

DRAINAGE.

Santa Rosa County has four rivers within its borders: the Escambia, which forms the western boundary; the Blackwater, in the central part of the county; the Yellow, which forms a part of its eastern boundary; and the East Bay in the Southern part of the county. These rivers all have tributary streams and creeks, some of considerable size and extent, which form a network of water courses all through the county and afford excellent natural surface drainage and means of irrigation. The main rivers are also navigable for some distance. The larger creeks are used extensively for rafting and floating mill timbers. Between Milton and Pensacola there is a regularly established line of water transportation.

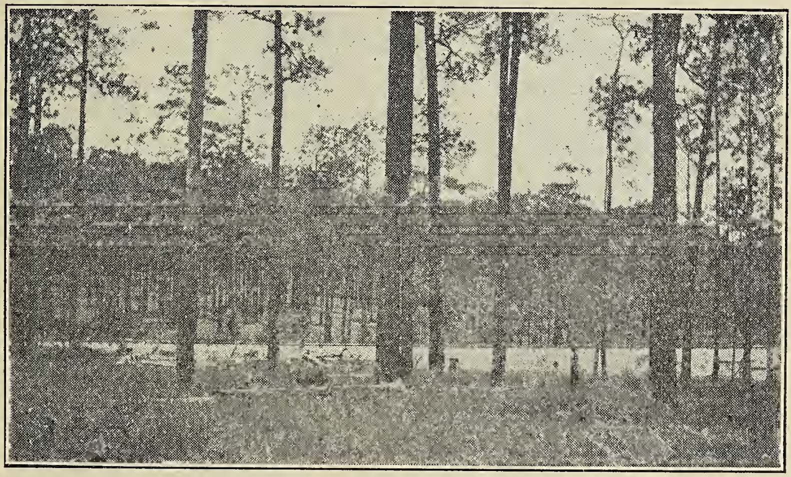

Fig. 8.—Rolling pine lands in Santa Rosa County.

AREA OF ARTESIAN FLOW IN SANTA ROSA COUNTY.

Up to the present time but little deep well drilling has been done in the county and the records of only a few flowing wells have been obtained, therefore, the area of artesian flow is undetermined. Along the Escambia Bay shore at Mulat there is a well that has a good flow at a depth of 181 feet. Other wells were reported farther up the bay. Flowing wells can without doubt be obtained along the entire water front and inland until the elevation becomes too great, and also for some distance along the several large streams emptying into the bays. The artesian head or pressure could not be measured for any of the wells in this county and therefore the height to which the water will rise above the surface is not accurately known. The water bearing formation from which these flows come is a coarse sand or gravel overlain by a series of sands and sandy clays. These sands and gravels are, as is well known, very variable and irregular in occurence and the depth at which flowing water is to be obtained, is likewise inconstant. The map on page 95 indicates the area in which flowing wells can probably be obtained in this county.

Bagdad is a large milling town situated about 1 mile south of

LOCAL DETAILS.

BAGDAD.

Milton on Blackwater River. The Stearns-Culver Lumber Company, operating a saw mill at this place, have several driven shallow wells ranging from 35 to 100 feet in depth, the average being about 75 feet. No deep wells have been drilled. The shallow wells furnish an abundant supply of soft water. These wells can be driven in a short time since they are small, ranging in size from $1\frac{1}{4}$ to 2 inches in diameter.

BLACKMAN.

About two miles west of Blackman postoffice in the northeastern part of the county the Falco Naval Stores Company have put down an artesian well. No definite information could be obtained regarding this well further than that it is between three and four hundred feet in depth and the water stands between 80 and 90 feet below the surface. The water is said to incrust boilers.

COBB.

The wells at Cobb range in depth from about 70 to 100 or more feet and terminate in sands and sandy clays. Wells are obtained at a more shallow depth but these do not furnish a sufficient amount of water. The water in these deeper wells stands quite a distance below the surface but the ordinary deep well pumps are used. In some instances the old style windlass is still in use.

MILLIGAN.

Milligan is near the eastern line of the county on the Louisville and Nashville Railroad and Yellow River. An abundant supply of water is obtained here from shallow wells at a depth of from 18 to 25 feet. No deep wells have been drilled. The saw mill at this place uses water from a nearby creek tributary to the Yellow River. These creeks are as a rule supplied by seepage springs and when such is the case furnish excellent water for boiler purposes.

MILTON.

Milton, the county seat and largest town in Santa Rosa County, is located on Blackwater River. The elevation as recorded by the Louisville and Nashville Railroad is 15 feet above sea. The principal source of water for all purposes is from driven or open wells ranging in depth from 15 to 75 or more feet. Although there are no deep wells in the vicinity, flowing artesian wells could in all probability be obtained. The elevation, along and near the water front at least, does not seem to be prohibitive.

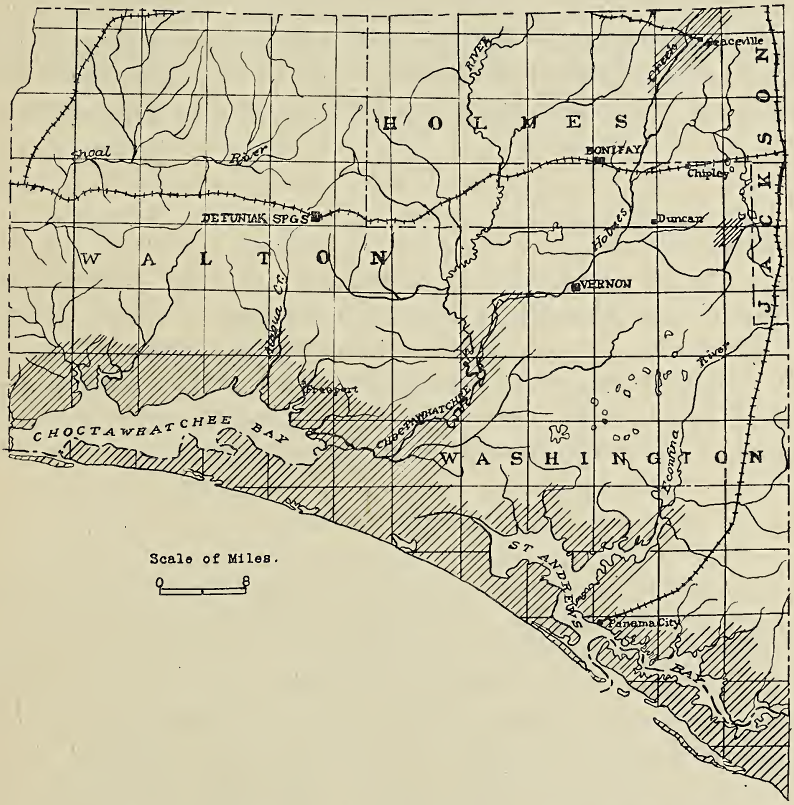

Fig. 9.—Map showing the area of artesian flow in Walton, Holmes and Washington Counties. The areas in which flowing wells can be obtained are indicated by shading.

A deep well about 16 miles northeast of Milton was sunk for Mr. H. Elliott by F. J. White & Company in 1910. The well is drilled to a depth of 366 feet and is six inches in diameter. The main water supply was encountered at the depth of 300 feet and no increase was obtained with increased depth. The water rises to within 85 feet of the surface.

MULAT.

Mulat is in the southwestern part of Santa Rosa County on Escambia Bay. One flowing well was obtained here at a depth of 181 feet. The well is owned by Mr. S. Otis and was drilled by F. J. White & Company. The water is used for general drinking purposes. The supply for the saw mill located here is from shallow driven wells ranging in depth from 40 to 43 feet. The water from this depth, while not flowing, is more desirable for boiler use.

PACE.

Two deep wells have been sunk at Pace by F. J. White & Company. One is reported to be 360 feet and the other about 500 feet in depth. The water from these wells was reported unsatisfactory for boiler use, as a consequence of which the wells are not now used. The supply of water used for the saw mill is from a pond close by and an open shallow well. The drinking supply is obtained from shallow driven wells from 20 to 80 feet in depth.

ROBINSON POINT.

Robinson Point some 8 miles south of Milton is on the western shore of Blackwater Bay. A flowing well which has been in use for several years is owned by the Robinson Point Milling Company. This well through some accident has lately stopped flowing. The depth was reported to be 100 feet and the water rose a few feet above the surface. Another well was sunk to a depth of 45 feet which now furnishes the mill supply. The head of this well is two feet below the surface. The quality of the water from this well is said to be better, for boiler use than that from the former which was slightly brackish at times. The general supply for all domestic purposes around Robinson Point is from shallow driven pumps from 15 to 35 feet deep.

WALTON COUNTY.

LOCATION AND SURFACE FEATURES.

Walton county extends from the State line to the Gulf. Holmes and Washington counties form its eastern boundary, while on its west is Santa Rosa county. The area is 1384 square miles or 885,760 acres.

The northwestern and northern parts of the county consist of a rolling type of country with a sandy soil and clay sub-soil. In the more hilly sections the yellowish and reddish sandy clays are exposed at the surface resembling the red hills so characteristic in other sections of the State. Within this northern area at Natural Bridge on Natural Bridge Creek is an exposure of a soft fine grained limestone. Other natural bridges and sinks also occur along this creek. The limestone exposed in this part of the county belongs to the Vicksburg formation.* The native growth immediately along the streams in the limestone section consists principally of water oak, hickory, dog wood and cedar. Some short leaf pine and cypress was also seen. This is the westernmost county in the State in which limestone lies at or close enough to the surface to have any influence on the general surface features.

Running practically across this county from west to east along or near the Louisville and Nashville Railroad is a very sandy ridge supporting a growth of dwarf oak. The ridge is three or four miles wide and lies on the divide between the territory tributary to the Yellow River and the territory draining through numerous small streams to the Gulf. The southern part of the county bordering the Choctawhatchee Bay is chiefly open pine land.

Euchee Valley is a characteristic small area lying in the eastern part of the county. This so-called valley is in reality the transition ground between uplands of the interior of the county and the valley of the Choctawhatchee River. It lies chiefly on the north side of Goose Creek and the west side of Sandy Creek, and consists of a succession of small hills giving a decidedly rolling topography. The hills of which Mossy Hill is the best known are outliers from the plateau section of the county. The forest growth includes hardwood and short leaf pine hammock. The clay sub-soil on the slopes lies usually near the surface. In many ways this valley resembles Holmes Valley on the opposite side of the Choctawhatchee River, both having been formed by the same processes.

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*Florida Geol. Surv., Second Annual Report, p. 56, 1910.

The whole of Walton county, except the small local areas such as Euchee Valley, is covered with an excellent growth of long leaf pine. A great deal of this timber has been cut away but large areas still exist that have not been turpentined. The saw mills, however, are cutting the timber as fast as capacity will permit, and it is only a matter of time until the pine will be entirely cut off.

ELEVATION.

The Louisville and Nashville Railroad crosses the county from east to west. The following elevations are given for towns along this road: Ponce de Leon (Holmes county and on tributary stream of Choctawhatchee) 73 feet; Argyle 254 feet; DeFuniak Springs 256 feet; Mossy Head 274 feet; Deerland 239 feet; Crestview 175 feet. From Crestview north to Florala, Alabama, the following are given: Campton, 172 feet; Falco 235 feet; Laurel Hill 235 feet; Cowan 173 feet; Svea 241 feet; Florala, Alabama, 214 feet. As will be seen this northern half of the county is high and is exceeded in elevation in the State only by the plateau section of Gadsden county. After leaving this elevated region and traveling southward there is a gradual decrease in elevation until the Gulf of Mexico is reached.

DRAINAGE.

Walton county has a well defined system of drainage and like the neighboring counties is well watered. The Choctawhatchee River which forms part of its eastern boundary has numerous tributary streams which intersect this portion. Likewise, Yellow River forming the extreme northwestern border together with Shoal River which unites with Yellow River in eastern Santa Rosa county, with their tributary creeks drain the entire northern half of the county. The drainage of the northeastern part of the county is in part subterranean since the Vicksburg Limestone is exposed at the surface and influences both the drainage and surface features. The southern half of the county is intersected with streams which empty into the Choctawhatchee Bay. Springs are numerous throughout the county. The springs feed to a great extent the different streams and consequently the waters are remarkably clear and pure. Where limestone crops out limestone springs are frequent and in the limestone portion of this county large springs occur which are the sources of rather large creeks.

AREA OF ARTESIAN FLOW IN WALTON COUNTY.

There are several flowing wells in southern Walton county along Choctawhatchee Bay which afford a large volume of water under strong pressure. Just how far inland these flows can be obtained in difficult to say since but little deep well drilling has been done in the county. The map on page 105 indicates, however, the area in which flowing wells can in all probability be obtained.

LOCAL DETAILS.

CRESTVIEW.

Crestview is in western Walton county and is the junction point of the branch line of the Louisville and Nashville Railroad from Florala, Alabama. Surface water wells are obtained here without difficulty and up to the present time no deep well drilling has been done.

DEFUNIAK SPRINGS.

DeFuniak Springs, the county seat and principal town, lies within the high, rolling pineland section of Walton county. An almost circular lake fed by springs gives the town its name. The elevation of the depot here according to the records of the Louisville and Nashville Railroad is 256 feet above sea level. The city is at present supplied with water from one deep well located at the pumping station. This well is 620 feet deep and was drilled by F. J. White & Company in 1908. In the process of drilling the diameter was reduced from 10 inches to 8 inches. The water is said to rise to within 85 feet of the surface.

FREEPORT.

Freeport is in southern Walton county bordering on Choctawhatchee Bay. Wells with an excellent volume of water under strong pressure are obtained here. Two wells have been drilled in the town and two about 3 miles south. These wells were drilled by F. J. White & Company in 1907. The well owned by the town of Freeport is 6 inches in diameter and reached a total depth of 183 feet. Another well for Messrs. J. C. Blackburn & J. N. McLain is 4 inches in diameter and 181 feet deep. This well had a pressure when measured September 22, 1910, of 6½ pounds, equivalent to a head of 15 feet above the surface. The town well mentioned above could not be accurately measured since all connections could not be cut off. About 3 miles south of Freeport on Choctawhatchee Bay the

Baker-Wakefield Company have a flowing well which is 8 inches in diameter and 210 feet deep. The pressure gauge on September 22, 1910, indicated a pressure of 15 pounds, equivalent to a head of 34.65 feet above the surface. The well is on low ground, only a few feet above the water level in the bay. Another well nearby owned by the Choctawhatchee Lumber Company has a depth of 189 feet and is 6 inches in diameter. This well had a pressure on the same date of 12½ pounds, equivalent to a head of 28.87 feet above the surface. The water from these wells is used for general mill supply. It is slightly hard but is used in boilers.

LAKE WOOD.

A well for the Britton Lumber Company was sunk at Lake Wood in 1905 to the depth of 604 feet. The well was commenced 10 inches in diameter but in the process of drilling was reduced to 6 inches. According to barometric readings the elevation here is 290 feet above sea. The water is said to rise to within 160 feet of the surface and from its continued use in the boilers a soft scale is formed.

LAUREL HILL.

There are no deep wells in Laurel Hill, the town itself having no city water supply. The typical wells in use here are the open dug wells which range from 50 to possibly 100 or more feet in depth. The well in public use in Laurel Hill is said to be 57 feet deep and terminates in sands and sandy clays. The so-called bored well from which the water is drawn up in long cylindrical bucket with the windless attachment is frequently used in this section.

HOLMES COUNTY.

LOCATION AND SURFACE FEATURES.

Holmes county extends north to the Alabama-Florida line. Holmes Creek and Choctawhatchee River form its eastern boundary separating it from Jackson and Washington counties respectively. On the south it is bounded by Walton and Washington counties and on the west by Walton county. The total area is 435 square miles, or 278,400 acres.

Aside from the swamp and alluvial lands bordering the streams and the short-leaf pine hammock growth on the slopes, Holmes county is almost wholly a long-leaf pine country. Most of the county has a rolling surface. The soils are prevailing sandy loams, and over much of the county a red clay sub-soil is found making desirable farming lands. A strip of open flatwoods is found running through this county along the east side of the Choctawhatchee River and having a width of from two to four miles. On the west side of this river the rolling clay lands reach as a rule to the river swamp, the open flatwoods not being present.

ELEVATIONS.

The following elevations are recorded at stations of the Louisville and Nashville Railroad traversing the southern edge of this county: Bonifay 120 feet; Caryville (near the county line but in Washington county) 72 feet; Westville 70 feet; Ponce de Leon 73 feet; Argyle (near the western boundary line but in Walton county) 254 feet. It will be noticed that the elevations given in Holmes county are at stations located on or close to a creek. Upon leaving these streams the country rises in elevation considerably.

DRAINAGE.

Holmes county is intersected by many streams and is consequently well drained and well watered. The Choctawhatchee River, which is navigable for medium-sized boats as far as Geneva, Alabama, flows through the central part of the county. Holmes Creek receives the drainage of the eastern part of the county. On a number of the streams large springs occur. Particularly is this true of Sandy Creek, a tributary of the Choctawhatchee River, on which are several springs of the characteristic blue limestone water. Morrison Spring the largest of these is near the mouth of the creek. Ponce de Leon Springs occur near the town of the same name.

ARTESIAN WELLS.

Flowing artesian wells have not been obtained in Holmes county. It is quite possible, however, that the formation reached by the wells at Graceville in Jackson county would also give flowing wells in the adjoining part of Holmes county.

LOCAL DETAILS.

BONIFAY.

Bonifay is the county seat of Holmes county and is located about four miles west of Holmes Creek and near the northern line of Washington county. The elevation at the depot here, according to the records of the Louisville and Nashville Railroad, is 120 feet above sea. An eight inch well was sunk here for the County by Mr. F. J. White in 1910. This well is 518 feet deep and is cased 388 feet. The water, which is hard, rises to within 60 feet of the surface. A second well is owned by Sessoms-White Lumber Company about one-half mile south of town. This well which is reported to be 398½ feet deep is eight inches in diameter and was drilled in 1906. The water is said to stand about 40 feet below the surface.

ELEANOR.

Eleanor is located in northeastern Holmes county a little west of Holmes Creek. Two wells have been drilled at this place by Mr. F. J. White. One of these is owned by Mr. James Williams and was drilled in 1906. It is six inches in diameter and 275 feet in depth being cased the entire depth. The water is said to come to within 30 feet of the surface. The second well is owned by the Geneva Lumber Company and is 400 feet deep.

WYNNLUM.

Wynnlum is in northeastern Holmes county. The Harper Lumber Company have a six inch well at this place 205 feet deep. It is cased 170 feet. The water stands 15 feet below the general surface level. The well was drilled by Mr. F. J. White in 1910.

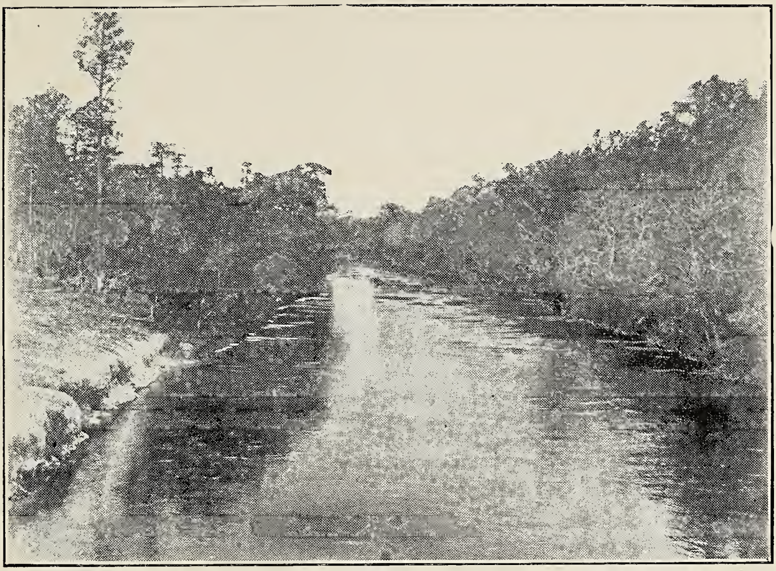


Fig. 1.—Chipola River in Calhoun County.

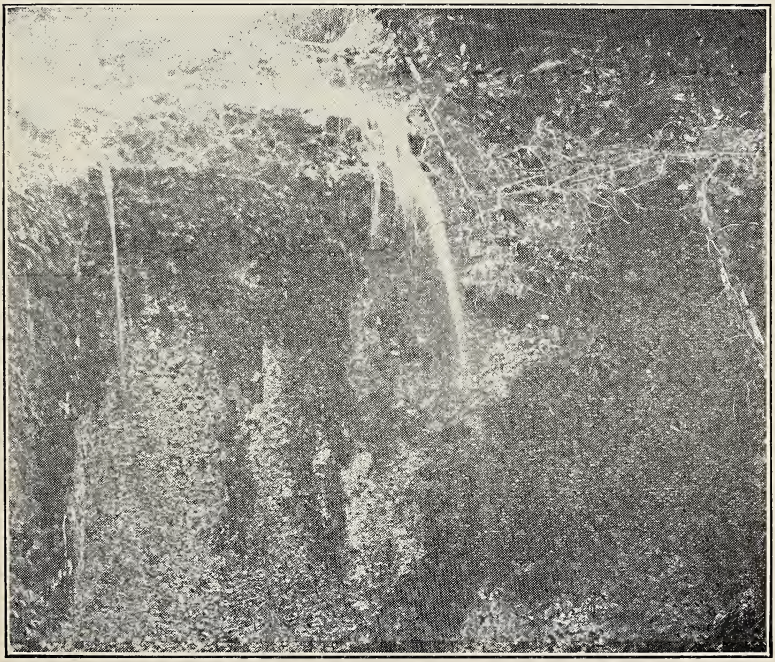
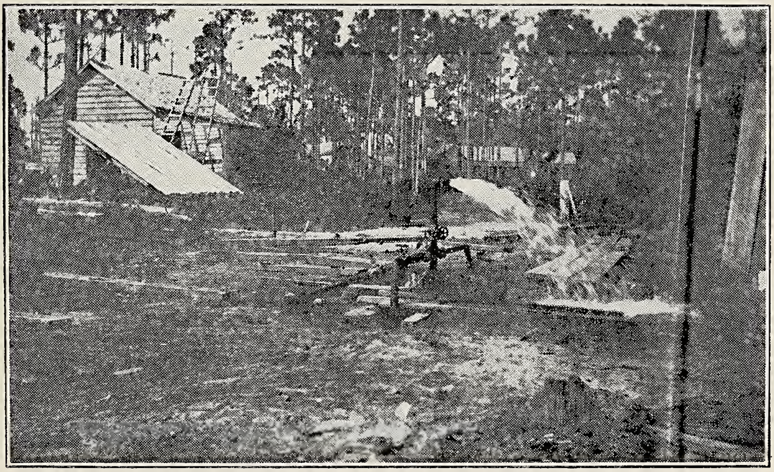
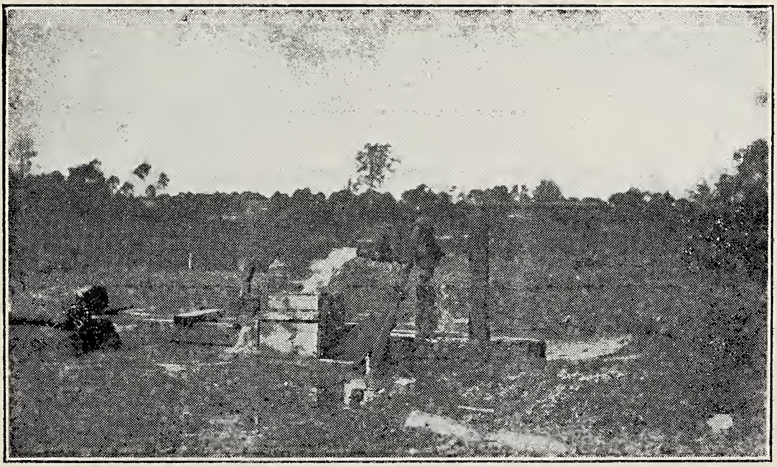


Fig. 2.—Falling Water sink, five miles south of Chipley, in Washington County.



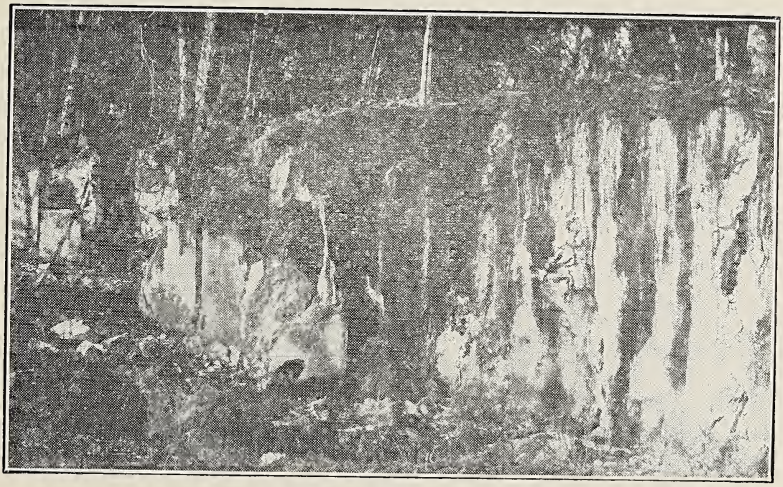


EXPLANATION OF PLATE 14.

Fig. 1.—Clay pit of the McMillan Brick Company, Molino, Escambia County.

Fig. 2.—Flowing well at sawmill of Baker-Wakefield Company, three miles south of Freeport, in Walton County.

Fig. 3.—Flowing well at sawmill of Choctawhatchee Lumber Company, three miles south of Freeport, in Walton County.

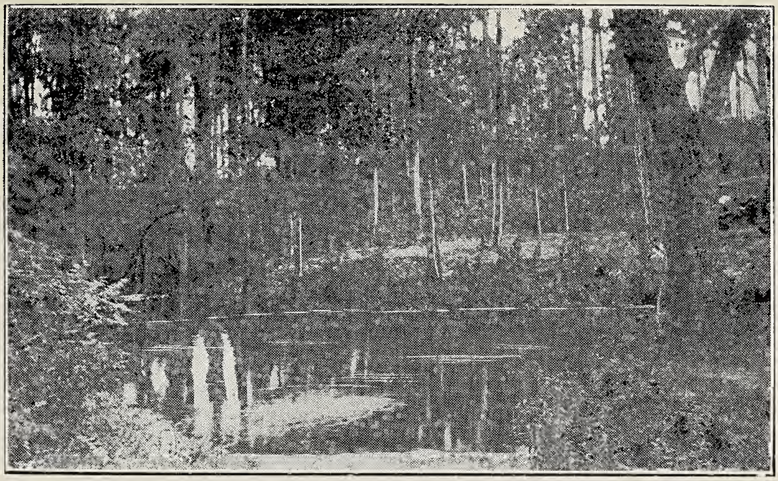


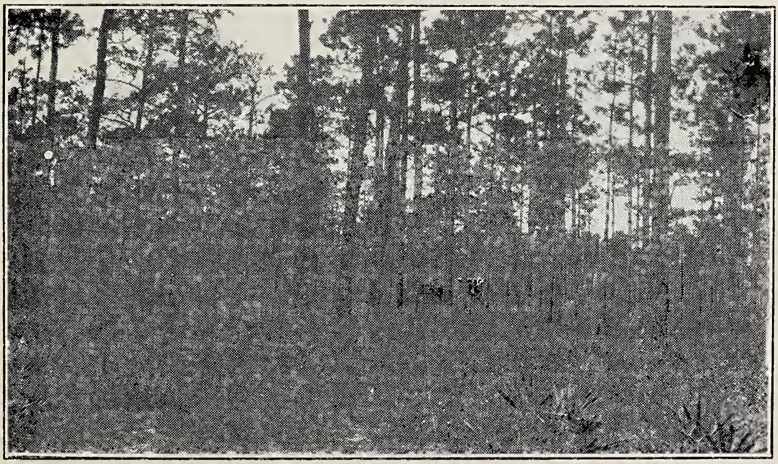
EXPLANATION OF PLATE 15.

Fig. 1.—Porters Pond, twenty miles south of Chipley, in Washington County.

Fig 2.—Exposure of Vicksburg Limestone near Duncan, in Washington County.

Fig. 3.—Open pine woods, four miles east of Bonifay, in Holmes County.





EXPLANATION OF PLATE 16.

Fig. 1.—Ponce de Leon Springs at Ponce de Leon, in Holmes County.

Fig. 2.—Open flatwoods, eight miles northeast of Cerrogordo, in Holmes County.

Fig. 3.—Pine lands west of the Chipola River, in Calhoun County.

WASHINGTON COUNTY.

LOCATION AND SURFACE FEATURES.

Washington county is bounded on the north by Walton, Holmes and Jackson counties, on the east by Jackson and Calhoun counties, on the south by the Gulf of Mexico and the western projection of Calhoun county, and on the west by Walton and Holmes counties. The total area is 1425 square miles or 912,000 acres.

The surface features of the county are quite diversified. The Vicksburg Limestone lies at or close to the surface over the northern part of the county and its influence on the topography is very evident. Near Duncan this limestone is quarried and presents a good exposure of the formation. The rock is used for building chimneys, and although soft when first quarried, it hardens on exposure. Sink holes are very common throughout this area. The best known of the sinks is Falling Water, about five miles south of Chipley, into which a small stream empties.

Upon leaving Duncan and traveling southward to Vernon a change is noted in the topography as well as in the character of soil and vegetation. The red hill section with its many lime sinks and exposures gives way more or less gradually to a gently undulating open pine woods type of country with broad or saucer-shaped valleys. These valleys are almost devoid of undergrowth except for tall grasses, and at times, in seasons of heavy rainfall, are no doubt covered with water for a short period. Long leaf pine grows in abundance on the uplands and along the valley slopes. Cypress is seen in the valley bottoms. No exposures of limestone or lime sinks were seen between Duncan and Vernon, and the drainage in this territory is apparently through open surface streams emptying into Holmes Creek on the west.

In the central part of the county is found a plateau of high pine land. The plateau is highest near its northern border and has a very gradual and scarcely perceptible slope to the south. It is a sandy long leaf pine region with little or no undergrowth other than wire grass. Occasional circular lakes occur which represents the first steps in the degradation of the plateau by underground solution. To the south the plateau passes gradually into the flat woods bordering the coast.

Intermediate between the plateau and the lower lands to the north and west is an extremely interesting section of country known as Holmes Valley. This area is from one to three miles wide and extends in a northeast to southwest direction, a distance of from

15 to 18 miles. The land is rolling or hilly. The drainage is by small streams that cut across the "valley" and flow into Holmes Creek. The native growth is short leaf pine and hardwood trees. Orange Hill and Oak Hill represent the eastward extension of this type of country.

Owing to the natural fertility Holmes Valley was settled early and is found referred to frequently in the early history of west Florida. Williams in his publications on west Florida, as quoted by Smith, *offers the suggestion that Holmes Valley represents an old lake bottom, this view being supported in the opinion of Williams by the persistent fertility of the land. The origin of the "valley" however is very evident. Erosion by underground solution has been more rapid in the northern part of the county where the limestone lies near the surface than in the central part of the county where, owing to its southward dip, the limestone lies at a considerable depth. Erosion has also been more rapid in the vicinity of Holmes Creek and the Choctawhatchee River. The result is that the northern part of the county, which in earlier times stood at an equal or greater level, is now lower by possibly 50 to 100 feet in elevation than the central part of the county. This so-called valley is in reality the transition grounds or foot hills between the lower lands to the north and west and the plateau to the south. Erosion is constantly encroaching on the plateau from the north so that the escarpment line of the plateau is constantly retreating southward. Orange Hill and Oak Hill are "outliers" from the plateau. That is they are local areas, retaining their original height or nearly so notwithstanding the fact that the surrounding land has been eroded to a lower level.

No better illustration of the effect of topography on soils can be found than in this section of Washington county. The level plateau of the central part of the county permits the accumulation of the sands on the surface as the underlying formations disintegrate. This section is therefore a sandy pine country. On the border line of the plateau, Holmes Valley, where there is considerable slope the surface sands are removed as fast as formed or nearly so. The parent formation is thus brought to the surface, soil formation is accelerated and continuously renewed, which results in persistently fertile soils. The flat lands along the river represent almost complete degradation, and here the sands accumulate to a greater or lesser extent.

That the plateau of the central part of Washington county is

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*U. S. 10th Census. Report on Cotton Production. pt. 2, pp 45, 1884.

being affected by underground solution is evident from the occasional sink holes which have formed most of which are filled with water forming lakes. Geologically speaking Holmes Valley is a temporary phase of land development and will retreat southward following the retreat of the escarpment bordering the plateau.

ELEVATIONS.

There are very few points in Washington county the elevations of which have been determined and these occur along the Louisville and Nashville Railroad traversing the northern edge of the county. No points in the interior have been determined accurately. Caryville in the northwestern corner is given as 72 feet above sea; Bonifay (on the boundary between Holmes and Washington counties) 120 feet, and Chipley 113 feet. The red hills of this northern area reach their climax in the vicinity of Orange Hill. Barometric readings show the hill to be at least 100 feet above the station at Chipley.

DRAINAGE.

The western part of Washington county is drained principally by Holmes Creek and its tributary streams together with Pine Log Creek and its tributaries. Both of these streams flow into the Choctawhatchee River. Econfina River in the southern portion empties into the North Arm of St. Andrews Bay and receives part of the surface drainage of this section. In addition subterranean drainage in this county plays a very important part. Sink holes. ponds, small lakes and many depressions which owe their origin to the dissolution of the underlying limestones are in evidence over the northern portion of the county. These natural solution cavities and basins receive the surface water which passes through these channels into the underground water supplies. Falling Water Sink, into which a small stream empties, has already been mentioned. Blue Pond Sink, so-called from the characteristic blue color of limestone waters, is also a well known locality. This pond is about seven miles south of Orange Hill. Porter's Pond is a larger body of water, but in all probability is of lime-sink origin.

AREA OF ARTESIAN FLOW.

Flowing artesian wells are obtained in Washington county on the lower land bordering the Gulf, and for an undetermined distance inland along the streams. A deep well drilled about six miles south of Chipley is said to have flowed at a depth of 1250 feet. The area in which flowing wells are obtained is indicated on the map on page 105.

LOCAL DETAILS.

MILLVILLE.

The German-American Lumber Company own a six inch flowing well at Millville which is reported to be 225 feet deep. The flow will rise about 10 feet above the surface. The water is hard and forms a scale in the boilers.

PANAMA CITY.

Several wells have been drilled at Panama City and flows obtained. A well 300 feet deep, owned by the Panama Ice Company, was drilled in 1908. It is eight inches in diameter and is cased 180 feet. The first rock is reported to have been encountered at the depth of 250 feet. The first flowing water was obtained just above this rock between the depths of 200 and 250 feet. The principal supply of water is obtained from about the depth of 280 feet. The well has a head of 13.1 feet above the surface or about 15.1 feet above the water in the bay. An analysis of the water from this well made in the office of the State Chemist, A. M. Henry, Analyst, showed it to contain 236 parts solids to a million parts water. The solids were reported to be composed of Iron Oxide, Silica, Calcium Carbonate, Sodium Chloride (Salt), and Magnesium Sulphate (Epsom Salts).

A well drilled in 1909 to be used as the source for the city water supply was sunk to a depth of 630 feet. This is also an eight well and is cased 200 feet. The elevation is 24 feet above sea. The water rises to within 10 feet of the surface or about 14 feet above sea, which is approximately the same head as the well of the Panama Ice Company. The principal supply of water comes from the depth of about 260 feet and it was stated that no increase was obtained with the increased depth of the well.

SOUTHPORT.

A six inch well completed in 1911 for the Southport Lumber Company by Messrs. Jaxon & Knapp reached a total depth of 435 feet and is cased about 300 feet. The water rises a few feet above the surface. The following is a log of this well as reported by Mr. Jaxon.

	Feet.
Sand	0-20
Black muck	20-45
Soft sandstone	80-125
Very hard sandstone	125-130
Blue clay	130-133
Soft yellow sandstone	133-250
Very hard sandstone	250-265
Kaolin like substance	265-275
Fine grained limestone	275-435

A second well at this place is owned by the Sale-Davis Company and was drilled by Mr. F. J. White in 1906. It is eight inches in diameter and reaches a total depth of 268 feet, the head of the well at this depth being one foot below the surface. The water is used for general mill supply and is hard and sulphurous, forming a scale in the boilers.

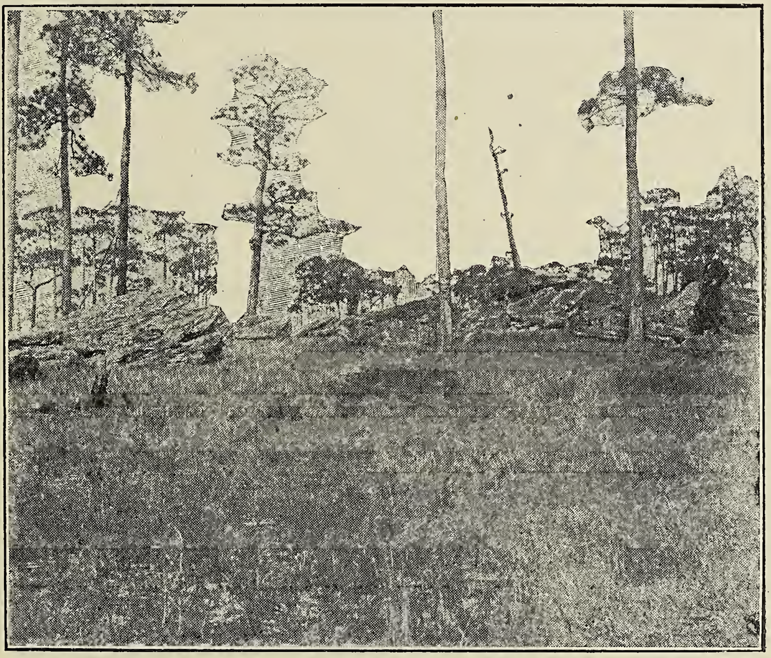

Fig. 10.—Exposure of sandstone ledges on Rock Hill in Washington County.

VERNON.

Vernon, the county seat of Washington county, is situated on

Holmes Creek. The water supply at this locality up until the year 1906 was from shallow surface water wells. During 1906 Mr. F. J. White sunk a well for the County to a depth of 190 feet. This well is located at the court house and was first used for the water supply for this building. However, it is now used as the source of public water supply for the town. It is six inches in diameter and cased 135 feet. The water rises in the boring to within 12½ feet of the surface. Rock is reported at the depth of about 40 feet. Since the sinking of this well the healthfulness of the community has been greatly improved.

WAUSAU.

Wausau is in northeastern Washington county about 8 miles east of Vernon and about 12 miles south of Chipley. Surface conditions are here different from the northern part of the county in that the red clay hills give place to a very sandy, gently undulating type of country. Clay, however, lies close to the surface locally as in places of lower elevations. A well drilled here in 1911 by Mr. F. J. White for the Wausau Lumber Company is located in somewhat of a depression. It is a six inch well and reached a total depth of 233 feet. The water rises to within 18 feet of the surface.

The following log, reported by Mr. White, shows the general character of the formations penetrated:

	Feet.
Mottled clay	0-95
Coarse sand	95-105
Limestone	105-115
Coarse yellow sand with some water	115-130
Gravel, water plentiful	130-150
Limestone, with layers of flint	150-162½
Fine sand	162½-168
Sandstone	168-172
White sand	172-190
Sandstone	190-198
Fine sand	198-220
Rock	220-233

JACKSON COUNTY.

LOCATION AND SURFACE FEATURES.

Jackson county lies west of the Chattahoochee and Apalachicola rivers, these rivers forming its eastern boundary. On the south it is bounded by Calhoun and Washington counties and on the west by Washington and Holmes counties, being separated from the latter county by Holmes Creek. To the north it extends to the Florida-Alabama line. The total area is 963 square miles or 616,320 acres.

The Vicksburg Limestone lies at or close to the surface throughout the northern part of the county and its influence upon the topography is very apparent. Many limestone springs, natural bridges, sinks and ponds occur besides numerous outcrops of the formation itself. The largest and best known of these springs is Blue Spring about six miles east of Marianna. This spring is the source of Blue Spring Creek which flows into the Chipola River. The solvent action of water upon the underlying limestones is the principal agent of erosion in this county.

The northwestern part of Jackson county includes chiefly rolling pine lands similar in character to the adjoining parts of Holmes and Washington counties. Along the Chipola River in the central part of the county is found a hammock type of country in which the red clay soils predominate. The native vegetation of the hammocks originally included many hard wood trees, although a large percentage of the land is now cleared for farming. The southern part of the county west of the Chipola River is of a more sandy character forming the eastward continuation of the upland section of Washington county. The eastern part of the county includes chiefly long leaf pine lands although on the slope leading to the Apalachicola River the hard wood hammock lands and the red clay soils reappear.

ELEVATIONS.

The following elevations are obtained from the surveys by the Louisville and Nashville Railroad which crosses the central part of the county from east to west: Sneads 97 feet; Cypress 146 feet; Marianna 89 feet; Cottondale 142 feet; Round Lake, in the southeastern part of the county on the Atlanta and St. Andrews Bay Railroad, is reported to be approximately 257 feet above sea. Compass Lake, about four miles south of Round Lake, is said to be 75 feet lower or about 182 feet above sea level.* It is probable that the highest elevations within the county are found near Round Lake.

DRAINAGE.

The Chattahoochee and Apalachicola Rivers on the east receive a great portion of the drainage of that part of the county. The Chipola River, flowing approximately through the center of the county from north to south together with its several tributary streams, drains the central part. A great many of these tributary streams are fed by springs and in fact in some instances they take their source from large limestone springs. The drainage of the western part of the county is mostly into Holmes Creek and thence to the Choctawhatchee River. Alligator Creek is the principal stream in this section.

In addition to the surface drainage a part of the drainage of this county is subterranean. The whole county as previously noted is dotted with many sink holes, ponds and natural bridges. These openings receive the surface waters which thus gain entrance to the permanent underground water supply. The blue or limestone springs are the natural outlets for the underground waters.

AREA OF ARTESIAN FLOW.

Two flowing artesian wells have been obtained at Graceville in the northwestern part of Jackson county. The flow in these wells is obtained at the depth of from 214 to 265 feet. The area in this part of the county over which artesian flow may be expected has not been determined as but few deep wells have been drilled.

LOCAL DETAILS.

AYCOCK.

The Aycock Brothers Lumber Company own an eight inch well at Aycock which was sunk by Mr. F. J. White. The well is 320 feet deep and is cased 60 feet. The water rises to within about twenty feet of the surface and is used for the general mill supply.

CAMPBELLTON.

Campbellton is in northwestern Jackson county along the line of the Atlanta and St. Andrews Bay Railroad. Unfortunately no elevations have been obtained at this point. Several wells have been drilled at this locality. The following two wells were drilled by Mr. F. J. White in 1907. One is owned by the town and is eight inches in diameter and 315 feet deep. It is reported cased 298 feet. The water is said to rise to within 35 feet of the surface. The second well also near the town is owned by Mr. Z. T. Stallings and is 190 feet deep. It is six inches in diameter and is cased to a depth of 60 or more feet. The head of this well is the same as the one above reported and the water is used for general domestic purposes.

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* U. S. Department of Agriculture, Advance Sheet, Bureau of Soils, Soil Survey of the Marianna Area, Florida, p. 6, 1910.

Another well was drilled here in 1910 by Messrs. Jaxon and Knapp for Mr. N. Dekle. This is six inches in diameter and is 250 feet deep. The following general log was given by Mr. Knapp:

	Feet.
Sand and sandy clays	0-40
Sand	40-225
Rock	225-250

GRACEVILLE.

Graceville is in the extreme northwestern part of Jackson county and on the east side of Holmes Creek. Flowing wells are obtained here at depths varying from about 242 to 287 feet. A well drilled for the town of Graceville in 1910 by Mr. F. J. White reached a depth of 287 feet. It is eight inches in diameter for 161 feet, at which depth the drill hole was reduced to six inches. The water flows about two feet above the surface and the volume of flow is estimated to be 20 gallons per minute. The water is hard but has no odor of sulphur. The well commenced flowing at the depth of 214 feet and an increase was noted at the depth of 265 feet. The following log was kindly given by Mr. C. D. Williams, driller for Mr. White:

	Feet.
Clay	0-50
Rotten limestone	50-100
Soft sandstone	100-165
Black marl	165-170
Blue marl	170-175
Hard sandstone	175-185
White shale	185-240
Gray sand (porous)	240-260
Limestone	260-263
Gray sand (porous)	263-287

A second flowing well at this place is located at the school house and was completed in 1904. The depth of this well is 242 feet. The well is eight inches in diameter. The water is hard and slightly impregnated with sulphur. An analysis of this water by the State Chemist of Florida showed the total solids to be 165 parts per million parts water.

A well drilled by Mr. White in 1910 for Mr. Monroe Kirkland reaches a depth of 225 feet and is cased 138 feet with six inch casing. The water comes to within twelve feet of the surface. The first rock encountered was reported to be at the depth of 138 feet the casing terminating on this rock.

GREENWOOD.

Several artesian wells have been drilled at and in the vicinity of Greenwood. These range in depth from about 150 to 175 or more feet. A well owned by Mr. H. B. Knapp was sunk in 1910. It is six inches in diameter and 160 feet deep, and is cased to a depth of 80 feet. The water is hard and stands about 40 feet below the surface. All of these deeper wells terminate in limestone.

Another well, drilled by Messrs. Jaxon and Knapp for Mr. W. Sorey in 1910, is 150 feet deep, four inches in diameter and is cased 122 feet. The water stands in this well about 50 feet below the surface. The following is a log of this well as given by Mr. Knapp:

	Feet.
Reddish sandy clays	0-40
Alternate beds of sand and clays	40,120
Limestone. The top of this limestone is very hard, flinty sometimes, then becomes soft and cavernous, cavities containing water	120,150

MARIANNA

Marianna is the county seat of Jackson county. The city is supplied with water from an artesian well 386 feet in depth. It is eight inches in diameter and is cased 232 feet. The water rises to within 90 feet of the surface. According to barometric readings the elevation at the well is 51 feet above the depot or about 140 feet above sea.

The Marianna Manufacturing Company own a six inch well located one mile west of the depot at Marianna. It is 150 feet deep and is cased to a depth of 125 feet. The water which is hard is used for the manufacture of ice and for general purposes.

At the State Reform School about 3 miles southwest of Marianna is a six inch well reported to be 276 feet deep. This well was drilled in 1906 by F. J. White and Company. The water rises to within 55 feet of the surface.

CALHOUN COUNTY.

LOCATION AND SURFACE FEATURES.

Calhoun county lies immediately west of the Apalachicola River, this river forming most of the eastern boundary separating it from Liberty and Franklin counties. It is bounded on the west by Washington county, and on the north by Jackson county. On the south it extends to the Gulf of Mexico. The county has a total length north and south, of something like 66 miles. The total area is 1067 square miles or 682,880 acres.

The northern part of Calhoun county west of the Chipola River includes a sandy pine upland which represents a continuation of the uplands of the adjoining parts of Jackson and Washington counties. East of the Chipola River one finds in the northern part of the county rolling pine lands having a red clay sub-soil. To this area the term "pine level" is locally applied. Near the Chipola River in the northern part of the county some hardwood hammock land is found. To the south approaching the dead lakes, the rolling pine lands pass gradually into open flat woods, while bordering the coast, is a section in which palmetto flat woods predominate.

ELEVATIONS.

No profile has been obtained of the railroads of Calhoun county and no exact levels are available. In general the surface elevation rises in passing inland from the coast and from the Apalachicola and the Chipola rivers. The most elevated part of the county is that lying west of the Chipola River adjacent to Washington county. This section of the county probably reaches the elevation of from 150 to 200 feet above sea level.

DRAINAGE.

The Apalachicola River forming the eastern boundary is the outlet for most of the streams within the county. The Chipola River, a tributary of the Apalachicola, flows through the central part of the county, from the north to south and empties into the Apalachicola River in the south central part of the county. A great many tributary streams to this river form a network of water courses over the county. A few streams on the southwest empty into the east arm of St. Andrews Bay, but aside from these all streams have their outlet through the Apalachicola and Chipola Rivers.

AREA OF ARTESIAN FLOW.

Flowing artesian wells are obtained along the Gulf coast in this county and may be expected for some miles inland especially in the valley of the Apalachicola River. The area in which flowing wells may be expected in this county is shown on the map on page 135.

LOCAL DETAILS.

BLOUNTSTOWN.

Blountstown, the county seat of Calhoun county is located on the Apalachicola River. One deep well has been drilled at this place from which desirable flowing artesian water was obtained. The well is four inches in diameter, 234 feet deep, and is cased 60 feet. It was drilled in 1910.

BUCKHORN.

One deep well is reported from Buckhorn. This well was drilled in 1910 for Gaskin and Kentz. It is four inches in diameter, 270 feet deep and is cased 160 feet. The water rises to within 15 feet of the surface.

PORT ST. JOE.

The Apalachicola Northern Railroad have a well at Port St. Joe 115 feet deep drilled in 1911. This well is four inches in diameter and is cased the entire depth. The water stands about five or six feet below the surface. In all probability a flowing well could have been obtained if the boring had been continued deeper, but such was not desired as the water from this well is used principally to furnish supplies for the machine shops and boilers. The water from the deeper wells is hard and is not so desirable for boiler use. The following is an approximate log of this well kindly given by Mr. George E. Dunan, Engineer of Roadway:

	Feet.
Grayish sand and several strata of shell......	0-40
Blue clay	40-55
Sand and sandstone	55-65
Stiff blue clay with mica flakes. At the depth of about 65 feet a cypress log was encountered	65-75
Very fine white sand becoming coarser at bottom of well. First water between 95 and 100 feet	75-115

The following is an analysis of the water from this well which was kindly made available by Mr. R. B. Coleman, General Manager of the railroad. Analysis by Regis Chauvenet & Brother, 620 Chestnut Street, St. Louis, Mo.:

	Parts per Million.
Calcium carbonate	147.43
Oxide of Iron	7.54
Magnesium carbonate	22.28
Sodium Chloride	49.37
Total solids	224.92

GADSDEN COUNTY.

LOCATION AND SURFACE FEATURES.

The Georgia state line forms the northern boundary of Gadsden county. The Ocklocknee River separates it on the east and south from Leon County. Liberty County forms part of its southern as well as western boundary, while to the extreme west the county extends to the Apalachicola River. The total area is about 500 square miles or 320,000 acres.

The surface features of the county differ from those of the adjoining counties on the east and west. Leon county on the east and Jackson county on the west present surface features giving evidence of underlying soluble limestones. Surface streams are few and such as occur have for the most part an underground outlet through sinks or solution cavities. Erosion in these counties is thus carried on principally by solution. Gadsden county, on the contrary, is intersected with many large and small surface streams which receive the drainage of the county and which have surface outlets emptying into the two rivers forming the east and west boundaries. Erosion in this county is thus mainly through mechanical wash.

In general the topography of the county is rolling, becoming broken as the Apalachicola River is approached on the west. The central portion forms a comparatively level plateau which lies on an average from 250 to 300 feet above sea. From this plateau, which divides the drainage, the slope is gradual to the eastern and southern boundaries of the county. This county is intersected by many streams, the largest of which is Little River. The slope to these stream channels is frequently quite steep. Near the Apalachicola River the country grows more hilly and broken. The streams in this part of the county head in a characteristic manner. The main streams have many tributaries and branches which are fed by the seepage springs. These springs have eroded deep channels or gullies which are locally called "steep heads." Usually these heads are not too steep to retain soil and support a growth of vegetation although occasionally the descent is almost precipitous. For an account of the conditions which produce these heads see the Second Annual Report of this Survey page 262.

The slope to the Apalachicola River along the western border of Gadsden county is abrupt and gives rise to a strip of short leaf pine country two or three miles in width. The strip of land is analagous in origin to the broken lands which border the Holmes

Valley and the Euchee Valley, and other broken lands which border the plateau. The considerable height at which the plateau lies above the river has resulted in the land being more hilly than elsewhere in Florida. The native growth is the short leaf pine, with some hardwood and other trees.

The plateau section which lies back from the river is an area of long leaf pine. Little River flows through the county and along this stream and its tributaries is developed short leaf pine hammock lands with red clay soils.

The soils of Gadsden county range from heavy red to yellowish sandy clays, supporting a growth of hardwood timber and short leaf pine, to light sandy soils with a clay sub-soil supporting principally a growth of long leaf pine. The red soils are found chiefly on the slopes to the streams. The sandy soils often with clay subsoils occupy the level plateaus. A soil survey of this county was made by the U. S. Bureau of Soils in 1904 from which a more detailed account of the soils may be obtained.

ELEVATIONS.

The following elevations in this county are taken from the records of the Seaboard Air Line Railway which crosses the county from north-west to south-east, and from the profile of the Apalachicola Northern Railroad which traverses the western border of the county from north to south. The elevation at Ocklocknee, a station on the Seaboard Air Line Railway on the Ocklocknee River, is 133 feet. At Midway about 4 miles west of Ocklocknee the elevation rises to 201 feet and at Quincy, some 12 miles west of Midway, to 251 feet above sea. This increase in elevation on going westward continues until Mount Pleasant is reached. Gretna is recorded as 294 feet and Mount Pleasant which is about 9 miles west of Quincy is 301 feet above sea. This is the highest point recorded by the Seaboard Air Line Railway in this county. Westward to the Apalachicola River the elevation gradually decreases, River Junction being recorded as 82 feet above sea.

Along the Apalachicola Northern Railroad the following elevations are given: River Junction at the junction with the Atlantic Coast Line Railroad 76 feet; Hardaway 304 feet; Greensboro 280 feet; Juniper 254 feet; Sedalia 218 feet. As shown by this profile Hardaway is the highest recorded point in the State, exceeding Mount Pleasant by 3 feet.

DRAINAGE.

Gadsden is a well-drained and well-watered county. The Apalachicola River on the west and the Ocklocknee River on the east are the two main water courses, the latter although the smaller stream, receives the greater portion of the drainage. Several of the streams within the county including Little River, Rocky Comfort, Bear, Telogia, Ocklawaha and Hammock creeks flow into the Ocklocknee River. The Apalachicola River although a much larger stream drains a comparatively small area of the county. The streams having this river for their outlet are North and South Mosquito, Flat and Crooked creeks. The streams of this county fed usually by seepage springs, carry an abundant supply of clear soft water and afford splendid opportunities for small water powers and for irrigation.

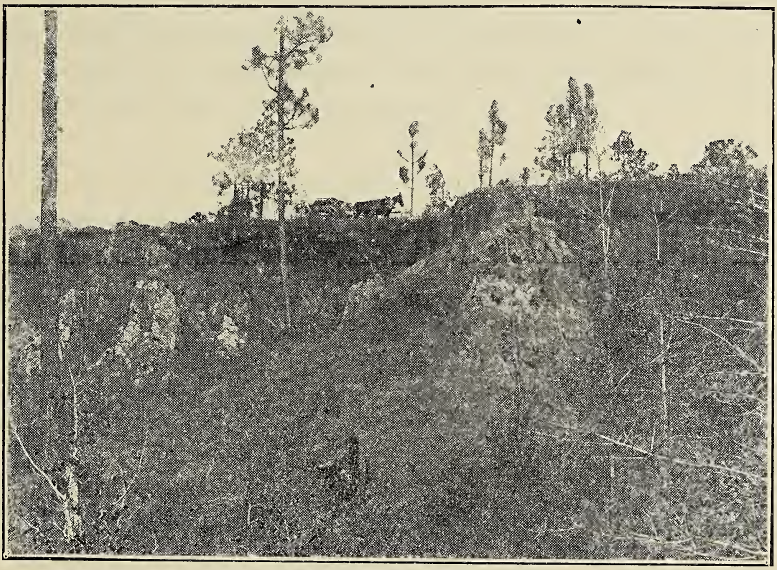

Fig. 11.—Exposure at the head of a small stream near Rock Bluff, in Gadsden County, showing a typical "Steephead."

ARTESIAN WELLS.

No flowing artesian wells have been obtained in Gadsden county. The water reached by the deep wells is under pressure, but not sufficient to cause a flow at the surface.

LOCAL DETAILS.

CHATTAHOOCHEE.

Chattahoochee is in northwestern Gadsden county. The town is located upon a high hill which faces the Apalachicola River. The surface material is red sandy clay overlying the Chattahoochee Limestone. A deep well was sunk here in 1905 for the State Hospital for the Insane. The well is six inches in diameter, 896 feet deep and is cased 400 feet. The water, which is reported to be salty, rises to within 160 feet of the surface.

GREENSBORO.

Greensboro lies in the western part of Gadsden county along the line of the Apalachicola Northern Railroad. The surface material here is sand and sandy clays in which the shallow wells of this locality terminate. No deep wells have been drilled.

HAVANA.

A number of wells have been drilled in and near Havana by Mr. B. H. Bolton. Those on record vary in depth from 200 to 280 feet. The Florida Tobacco Company has one well 280 feet deep and six inches in diameter. The Havana Tobacco Company has a well drilled in 1907. It is six inches in diameter and 266 feet deep, and it is cased to a depth of 150 feet. The water rises to within 90 feet of the surface. These two wells are typical of the artesian borings at this locality.

QUINCY.

Quincy is the county seat of Gadsden county and is located near the central part of the county. The elevation at the depot of the Seaboard Air Line Railway here is 251 feet above sea. The city water supply is taken from an artesian well 766 feet in depth. This well was commenced ten inches in diameter but in the process of drilling was reduced to six inches and is cased to a depth of about 500 feet. The water is hard and has a slight taste of sulphur when first pumped. The water in the well is said to stand about 70 feet below the surface.

Several other artesian wells have been drilled at this locality ranging in depth from about 602 to 940 feet. The shallow water wells are also in common use. These range in depth from 50 to 90 or more feet and give a good supply of soft water.

LIBERTY COUNTY.

LOCATION AND SURFACE FEATURES.

The Apalachicola River forms the entire western boundary of Liberty county separating it from Calhoun county. On the north it is bounded by Gadsden county; on the east by the Ocklocknee River, which divides it from the counties of Leon and Wakula; and on the south by Franklin county. The total area is about 725 square miles or about 464,000 acres.

The northwestern part of this county consists of the broken red sandy clay hill type which extends down from Gadsden county. This parallels the Apalachicola River along which in this county are some high bluffs which afford excellent exposures of the underlying formations. Among these are Aspalaga, Rock and Alum Bluffs. From Bristol south the country is more level.

ELEVATION.

The Apalachicola Northern Railroad passes through this county from north to south. A profile of this road has been furnished by Mr. R. B. Coleman, General Manager. The following elevations above mean low tide are taken from this profile. In passing through the county from south to north the elevation rises gradually. The elevation of the several stations is as follows: Sumatra 22 feet; Criglar, 55 feet; Wilma, 62 feet; Zion, 74 feet; Deerhunt, 82 feet; Liberty, 94 feet; Causey, 113 feet; Telogia, 115 feet; Hosford, 100 feet; Collins, 158 feet; Millman, 186 feet; Eddy, 200 feet. Farther north in Gadsden county elevations slightly above 300 feet are reached.

DRAINAGE.

Liberty county has a great many surface streams all through the interior of the county. In addition to these smaller streams the rivers defining its eastern and western boundaries assist in the drainage of the county. The Apalachicola River on the west receives most of the drainage. New River in the south central part empties into Crooked River in Franklin county. Telogia Creek in the northeast part is a good sized stream emptying into the Ocklocknee River on the east.

AREA OF ARTESIAN FLOW.

No flowing artesian wells are recorded in Liberty county. It is probable, however, that flowing wells can be obtained in the southwestern part of the county along the Apalachicola River. The water in a well 495 feet deep at Hosford near the northern line of the county is reported to rise practically to the surface level.

LOCAL DETAILS.

BRISTOL.

Bristol, the county seat, lies in northwestern Liberty county along the Apalachicola River. No deep wells have been sunk at this locality, the shallow driven pumps and open wells being in common use. The surface formations here include sandy clays to a considerable depth in which most of the shallow wells terminate.

HOSFORD.

Hosford is in northern Liberty county on the Apalachicola Northern Railroad. The elevation at the depot is approximately 100 feet above sea. One deep well was sunk here in 1910 for the Graves Lumber Company by the Gay Artesian Well Drilling Company. The well is 495 feet deep and is two inches in diameter. The water, which is hard and charged slightly with hydrogen sulphide, rises to the surface.

FRANKLIN COUNTY.

LOCATION AND SURFACE FEATURES.

Franklin county lies bordering the Gulf coast. On the north it extends to Liberty county; east to the Ocklocknee River; which separates it from Wakulla county; south to the Gulf of Mexico; and west to Calhoun county. The Apalachicola River forms most of this western boundary. The total area is 731 square miles or 467,840 acres.

In general the surface of the county is level. The principal timber growth is long leaf pine. In the river swamps and places of lower elevation and of deficient drainage, other growths consisting of different hardwoods and shrubbery, replace the pine.

ELEVATIONS.

A profile of the Apalachicola Northern Railroad has been kindly furnished by Mr. R. B. Coleman, General manager, from which the following elevations in the county are taken: Apalachicola 5 feet; Franklin 8 feet; Beverly 10 feet; Fort Gadsden 20 feet; Coline 26 feet; Sumatra (near the boundary line between Franklin and Liberty counties) 22 feet. The highest point along the line of railroad in this county is near Sumatra. The contour rises to 34 feet and maintains this level for about a mile. All elevations given are above mean low tide.

DRAINAGE.

The main water courses in this county are the two rivers defining the eastern and western boundaries. The Apalachicola River on the west is the largest stream and before entering the bay at the city of Apalachicola widens out into several channels or bayous occupying a width of several miles. The Ocklocknee River on the east receives the drainage of this part of the county. This river together with Crooked River forms St. James Island. New River flows through the east central part of the county and empties into Crooked river on the south.

AREA OF ARTESIAN FLOW.

Flowing artesian wells are obtained along the Gulf coast in this county from near Carrabelle to the west line of the county. Flowing wells are also to be expected in the lowlands bordering the Apalachicola River. The area of flowing wells in this county is indicated on the map on page 135.

LOCAL DETAILS.

APALACHICOLA.

Apalachicola is the county seat of Franklin county and is located on Apalachicola Bay. The city is supplied with water from an artesian well 363 feet deep. The well is six inches in diameter and is cased 280 feet. The water rises to within about six feet of the surface. A second well owned by the city, located near the bay shore, is 620 feet deep and eight inches in diameter. This well is not now in use. The water rises about six feet above the surface and the volume of flow when measured September 16, 1910, was eight gallons per minute.

The Apalachicola Ice Company own two artesian wells, one 450 feet and the other about 337 feet in depth. The deeper well is three inches in diameter and is cased 110 feet. The water rises about six feet above the surface. This well is not in use. The second well 337 feet in depth is six inches in diameter and is cased 98 feet. The water does not flow but comes to within five feet of the surface. The water from this well is preferred to the deeper well water since it is not so hard.

Flowing wells can be obtained at this locality along the bay shore at depths varying from about 325 to 620 feet. At the latter depth the water in the city well contained salt and was therefore not used. The waters from the more shallow wells are impregnated with sulphur and are hard. Across the bay on St. Vincent Island flowing wells are also obtained. Dr. R. V. Pierce has two flowing wells here drilled by the Dixie Well Works which furnish an abundant supply of water.

Three miles north of Apalachicola the Apalachicola Northern Railroad drilled a well to the depth of 112 feet. The water at this depth is soft and desirable for use in boilers. The head is about 5 feet below the surface. A cypress log was encountered in the drilling at the depth of about 65 feet. In several other instances logs have been reported while sinking wells along the coast at this locality.*

CARRABELLE.

Carrabelle is in east Franklin county on St. James Island and is the terminus of the Georgia, Florida and Alabama Railway. Several deep wells have been drilled at this locality. The Franklin

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*Florida Geological Survey, Second Annual Report, P. 153, 1910.

Lumber Company have a well which is reported to be 300 feet in depth. It is two inches in diameter and is cased 300 feet. The water, which is a hard sulphur water, rises five or more feet above the surface. The principal supply of water is said to have been encountered at a depth of about 200 feet.

LEON COUNTY.

LOCATION AND SURFACE FEATURES.

Leon county extends to the Georgia state line; east to Jefferson county, south to Wakulla county and west to the Ocklocknee River, which separates it from the counties of Gadsden and Liberty. The total area of the county is approximately 730 square miles or 467,200 acres.

This county, like the adjoining counties on the east and west, includes two topographically distinct divisions, a northern upland section and a southern area of lesser elevation. The dividing line between these two sections crosses the county in a zig-zag course from east to west, passing two and one half miles south of Tallahassee. That part of the county north of this line is prevailingly a rolling, well-drained, and more or less hilly country. South of this line, the country, although including some low sand hills, and gentle swells, is prevailingly level pine land. The surface elevation in the northern half of the county ranges from 100 to 250 or more feet above the sea. The southern part of the county ranges probably from 50 to 100 feet above sea. From the last of the hills in the upland section one may look across the southern part of Leon and across Wakulla county to or nearly to the Gulf of Mexico.

The formation found in the northern part of the county is a deposit of clayey sands, the sand as a rule predominating and giving a gritty character to the material. On the other hand, clay partings are found in the formation and local clay lenses occur. Calcareous and phosphatic nodules are numerous. This formation is universally distributed over the northern part of Leon and adjoining counties and is seen in all public roads and railroad cuts. The formation is somewhat indefinitely stratified, and frequently is cross bedded, giving evidence of having been accumulated in conflicting currents. The clay intermixed with the sand is in a finely divided condition and acts to some extent as a cementing substance, giving a feeble coherence to the sand.

Upon being affected by the processes of decay the formation undergoes well marked and characteristic changes. The clay producing minerals partly disintegrate; the small constituent of iron becomes oxidized and stains the formation red. Another early effect of decay is the obliteration of the stratification lines giving the formation the massive appearance seen in all shallow cuts. The iron-clay pebbles so abundant in some localities on and near the surface are also formed in the decay of this formation. Three well marked stages of decay may often be seen in a single exposure. Nearest the bottom of the deepest cuts the material appears mottled and blotched, being iron-stained in streaks and patches where surface waters have permeated. This stratum of least decay is variable in thickness, often amounting to eight or ten feet. Above this, nearer the surface, is a more completely decayed stratum. This is uniformly colored red, and is usually more or less loamy in character. Above this red loam is found a surface stratum of loose sand. The sand may be ochre yellow or light yellow. The amount of clay remaining in the sand and in this top stratum is determined by drainage conditions, but usually sufficient clay remains to give a loamy character to the sand.

The loose top sands and the red clay loams form the soils. However, the character of the soils is further affected by the conditions under which it has accumulated, and several soil types are evident.

In the more or less hilly or rolling sections the loose top sand does not accumulate to any considerable thickness, being removed by surface wash as rapidly as formed. In such areas the soil is red in color and loamy in character, and has as a sub-soil the red clay loam described above. Soils of this type cover large areas in Leon county. In the government soil surveys they are classed as the Orangeburg series of soils.

While this type of soil is found on the slopes and on the rolling lands, generally, on the level upland plateaus a different type of soil accumulates. On the level plateaus there is practically no surface wash and the sand resulting from the decay of the clayey sands accumulates to a considerable depth. These sands, moreover, are subject to the continued leaching effect of the rains. The result is that most of the loose clay particles are removed from the sand and carried to a greater depth. Under these conditions the sands lose their bright red color and become ochre colored or pale yellow. These pale and more or less loamy sands occupy the level plateaus in Leon county. They are classed in the government reports as Norfolk series of soils. Several types of Norfolk soils are distinguished depending upon the texture of the soil and the character of the sub-soil.

These two kinds of soil, the red loams found upon the hillsides and on rolling lands, and the light yellow soils found on the level uplands, occupy the greater part of the area of northern Leon county.

In addition to these prevailing types, the light yellow soils of the plateaus, and the heavier red soils of the slopes, other soil types of lesser extent are found in both the northern and the southern parts of the county. One of the characteristic features of northern Leon county, and one that accounts for much of the scenic beauty of this region, is the presence of numerous small and large lake basins and valleys formed by solution of the underlying limestone. In these valleys light colored loamy sands not unlike the sands of the plateaus accumulate. There are likely to be some distinctions,

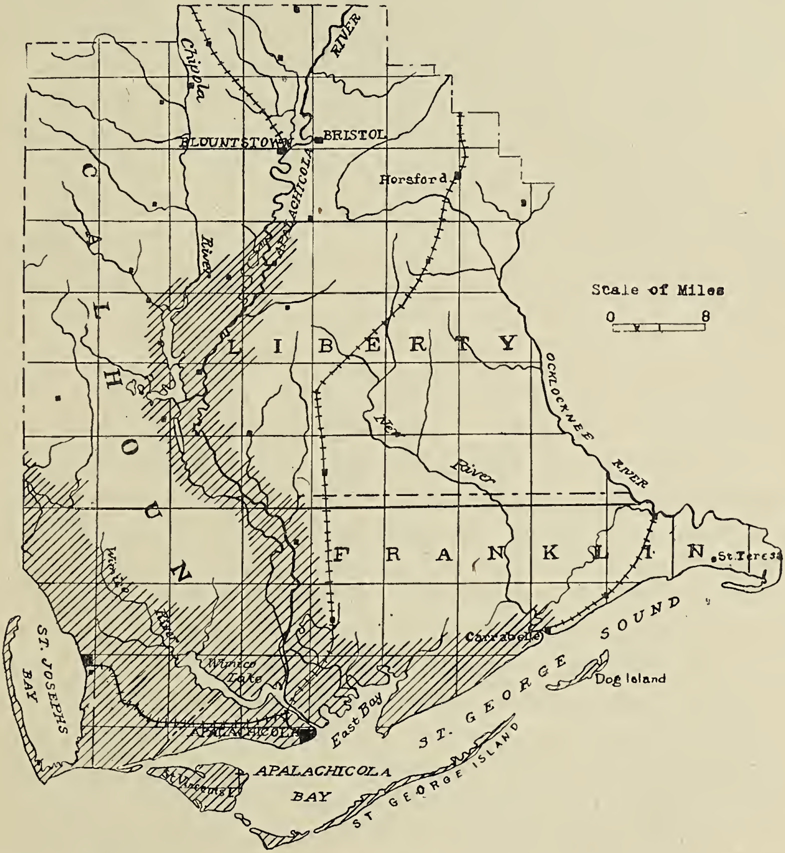

Fig. 12.—Map showing the area of artesian flow in Calhoun, Franklin and Liberty Counties. The area in which flowing wells can be obtained is indicated by shading.

however, as the sands of the plateaus are purely residual having been formed in place by the decay of the underlying material, while the sands of the valleys are of mixed origin. In the valleys the sands of residual origin have been added to by more or less material washed and blown from the surrounding slopes. Such basins are numerous and variable in size. Many are permanently occupied by lakes. Some of the smaller basins which have become so thoroughly filled with sand and other detrital material as no longer to contain water during any part of the year, support a scattered growth of live oaks and are known as "Live Oak Flats."

The largest of the solution basins in the county are those occupied by lakes Iamonia, Jackson, Lafayette and Miccosukee, the latter lying adjoining the Jefferson county line. These basins, in season of normal rainfall, are occupied during a part of the year by shallow lakes, but in seasons of reduced rainfall, they become entirely dry, the water having escaped into the underlying limestone. Lake Iamonia lies near the northern line of the county. It is a valley or basin from one to one and one-half miles wide and twelve or thirteen miles long, including about 6500 acres. Lake Jackson is irregular in outline but includes about 4500 acres. Lake Lafayette occupies a narrow valley from one-half to one mile wide and about five and one-half miles long, including about 2500 acres. These lakes have many interesting features in common. All occupy basins formed by solution. From all of them water escapes through sink holes into the underlying limestone. The boundaries of all of them are sharply marked on at least one side by abrupt bluffs, the basins lying from 50 to 100 feet below the general level of the surrounding uplands. The soil in these lake bottoms is, as might be expected, mixed and variable in character. Those parts of the lakes which are frequently dry have sandy soils, the sand having been washed and blown in. Other parts of the basins where water stands during a considerable part of the year have an accumulation of more or less muck, the water having acted as a preservative to the vegetable matter.

The southern part of the county which differs from the northern part in its topographic features likewise includes different types of soils. In the southwestern part of the county is found an extensive area, six to seven miles wide by fourteen to fifteen miles long, which, although sufficiently elevated, is nevertheless so level as to be imperfectly drained. Under these conditions a type of soil unlike that of the northern part of the county is developed. Numerous bay galls dot the surface, these being small densely wooded swamps. The timber growth is long leaf pine, the undergrowth, where not too wet, being saw palmetto and wiregrass. Land of this type is practically always underlaid at a depth of from eighteen inches to two feet by a stratum of sand more or less cemented with organic matter giving it a dark chocolate color. This stratum of sand becomes very hard during the dry season and interferes seriously with the free movement of soil moisture. It is known as hardpan. Drainage will materially improve the character of this land, and in fact the borders of the area where crossed by the numerous small streams that are cutting their way back into the uplands, exhibits a different type of soil the hardpan and palmetto being largely absent and the soil well drained.

Lying immediately south of Tallahassee is a section of country from one to three miles wide and fifteen to sixteen miles long which is very sandy and known as the "sand hills." Although well drained by reason of the open character of the soil, it is doubtful if the actual elevation of the sand hills exceeds that of the level poorly drained land lying further west and referred to above. To the south the sand hills grade into level pine lands.

Of the several soil types the light yellow sandy loams are very easily farmed and are excellent for trucking and other special crops as well as satisfactory soils for general farming. The red soils which are found extensively in the county are, by reason of their greater clay content, heavier soils and well adapted for general farming. They are found as already stated on the slopes and rolling lands, and when protected as they easily are, from excessive surface wash they have great endurance and are lasting soils. The slow removal of the top sands which constantly brings the red soils to the surface on the slopes permits the rapid renewal of the soils from the parent formation beneath, the new soil bringing with it new stores of plant food. In this renewal of the soil made possible by the removal of exhausted top soils is found the explanation of the great endurance characteristic of the red soils of this and surrounding counties.

ELEVATIONS.

There are but few points in the county the elevations of which have been determined. According to the records of the Seaboard Air Line Railway the elevation of the depot at Tallahassee is 83 feet above sea level. The State Capitol building is about 115 feet above the depot, or approximately 200 feet above sea level. Some of the hills in the vicinity of Tallahassee probably reach an elevation of 250 feet. Chaires, near the eastern boundary of the county, has an elevation, according to the records of the Seaboard Air Line Railway, of 60 feet, and Ocklocknee, near the western boundary of the county has according to the same surveys, an elevation of 133 feet above sea.

LOCAL DETAILS.

CHAIRES.

Chaires is in eastern Leon county on the Seaboard Air Line Railway. The surface material here is the red sandy clays under which at a comparatively shallow depth limestones are found. The shallow wells range in depth from 15 to 30 feet terminating in the sandy clays. These are the common type of wells in this vicinity. A well from which the Seaboard Air Line pumps its water for boiler use here is said to be about 35 feet deep. The well at this depth enters the limestone formation which was encountered about 30 feet below the surface. The elevation at the depot here is 60 feet above sea and the well is located near the depot at about the same level. The water, which is hard, rises to within 21 feet of the surface.

TALLAHASSEE.

Tallahassee, the capital of the State and county seat of Leon county, is situated about the center of the county near the southern limit of the rolling red clay hills. The hill upon which the Capitol building is located has an elevation of about 200 feet above sea. The elevation at the depot here is, according to the records of the Seaboard Air Line, 83 feet above sea. The city is supplied with water from three artesian wells ranging in depth from 400 to 717 feet and in diameter from 8 to 12 inches. These three wells are located at the pumping station about three blocks east and six blocks south of the postoffice. Two of the wells are 400 feet in depth and the third is 717 feet deep. All the wells are reported cased 190 feet. The water rises to within about 92 feet of the surface. The following analysis of the water from this well shows the character of the artesian waters in this section. Analysis made in the office of the State Chemist, A. M. Henry, Analyst:

Constituents.	Milligrams per Liter, Approximately Parts per Million.
Silica (SiO_2)	7.
Chlorine (Cl)	7.
Sulphate radicle (SO_4)	2.
Phosphate radicle (PO_4)	0.
Carbonate radicle (CO_3)	0.
Bicarbonate radicle (HCO_3)	143.
Sodium and Potassium (Na K)	31.
Magnesium (Mg)	2.
Calcium (Ca)	41.
Iron and Alumina (Fe Al)	8.
Loss on ignition	35.
Total dissolved solids	165.

The Middle Florida Ice Company have two wells at Tallahassee used in the manufacture of ice. One well is 130 feet deep, six inches in diameter and is cased 84 feet. The water, which is hard, is said to rise to within 56 feet of the surface. The second well is eight inches in diameter and 375 feet in depth. It is reported cased to a depth of 108 feet and the head is said to be 66 feet below the surface. This latter well was drilled in 1894, the former in 1908.

Several wells have been sunk throughout the northern area of Leon county. These wells are on private estates and supply waters for general domestic purposes. No logs of any of these have been obtained and likewise no samples of the drillings. Most of these wells are 4½ inches in diameter and range in depth from 200 to 355 feet.

WAKULLA COUNTY.

LOCATION AND SURFACE FEATURES.

Wakulla county lies immediately south of Leon county. It is bounded on the east by Jefferson county and extends on the south to the Gulf of Mexico. The Ocklocknee River separates it on the west from Gadsden and Liberty counties. The total area is 601 square miles, or 384,640 acres.

Wakulla county has in general a level or gently rolling surface. Over the eastern half of the county limestone is frequently exposed at the surface and where not exposed lies at no great depth, influencing to a marked degree the surface features. The circulation of water below the surface has dissolved portions of these underlying limestones as is shown by the many sinks, subterranean passages, limestone springs and natural bridges found over the county. Lost Creek, which flows through the north-central portion of this county, "sinks" and "rises" forming several natural bridges. Many of the streams in the county have no surface outlet but pass into the earth through these solution cavities. Wakulla Springs, about two and one-half miles northeast of Crawfordville, is one of the natural outlets of the deep waters in this county. This spring covers an area of about four acres and is 118 feet deep.* The spring is the source of the Wakulla River.

ELEVATIONS.

Wakulla county is crossed by two railroads, the Georgia, Florida and Alabama Railroad, which passes through the central part of the county, and the Seaboard Air Line Railway from Tallahassee to St. Marks. St. Marks is given by the Seaboard Air Line as eight feet above sea. No other elevations along this line in this county are given.

DRAINAGE.

The Ocklocknee and Sopchoppy rivers on the west receive the surface drainage of this part of the county. The north-central part of the county is dotted with many sink holes and solution channels through which means surface waters find entrance into the underlying porous limestones. The eastern part of the county is drained principally by St. Marks, Wakulla and East rivers.

ARTESIAN WELLS.

Flowing artesian wells have not been obtained in Wakulla county. The limestone formations which lie at or near the surface in the eastern and northern parts of the county dip to the south and west and are overlaid in the southwestern part of the county by later formations. From this fact it is possible that flowing wells may be secured in the southwestern part of the county along the Ocklocknee River. No record, however, is available of test wells in this section.

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*U. S. Geol. Surv. Water Supp. & Irr. Paper, 102, p. 273, 1904.

LOCAL DETAILS.

BENHADEN.

A well three miles east of the postoffice at Benhaden is owned by Mr. W. N. Strickland. It is 153 feet deep and is cased to a depth of 60 feet. The boring is 2½ inches in diameter. The water rises to within 19 feet of the surface. The following is an analysis of water from this well made by the State Chemist:

Constituents.	Parts per Million.
Chlorine (Cl)	14.
Carbonate radicle (CO_3)	0.
Bicarbonate radicle (HCO_3)	175.
Loss on ignition	40.
Total dissolved solids	200.

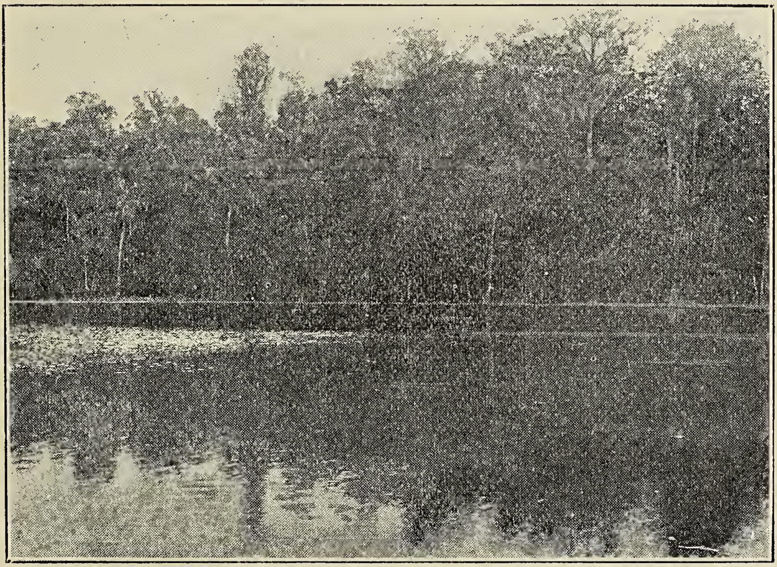

Fig. 13.—Wakulla Springs in Wakulla County.

CRAWFORDVILLE.

Crawfordville is the county seat of Wakulla county and is located near the center of the county. The surface material here is a sandy loam, below which limestones are generally found at no great depth. The town has no city water supply and no deep wells occur in the vicinity. The supply is principally from open shallow wells, which furnish as a rule a hard water. Cisterns are in use to some extent.

PANACEA.

Panacea is located on the Gulf coast in southern Wakulla county. The water supply is from the Panacea Mineral Springs, which include a number of springs. The following analyses of the waters from the springs were made by Dr. V. Coblentz, New York City, November 28, 1898.

Spring Number 1.

Constituents.	Grains per U. S. Gallon.	Parts per Million.
Sodium Chloride	135.976	2331.160
Magnesium Chloride	16.354	280.371
Calcium Chloride	3.213	55.083
Sodium Sulphate	8.407	144.128
Magnesium Sulphate	4.441	76.136
Calcium Sulphate	3.213	55.083
Calcium Carbonate	20.475	351.021
Ferrous Carbonate	0.882	15.120
Magnesium Carbonate	1.051	18.018
Silicic Acid (SiO_2)	0.893	15.309
Alumina	Traces	Traces
Organic Matter (Loss on Ignition)	3.210	55.031
Total	198.118	3396.415

Spring Number 2.

Sodium Chloride	23.664	405.693
Magnesium Chloride	15.080	258.532
Calcium Chloride	0.870	14.915
Potassium Chloride	1.452	24.892
Sodium Sulphate	2.307	39.550
Magnesium Sulphate	3.770	64.632
Calcium Sulphate	0.382	6.548
Iron Carbonate	0.672	11.520
Calcium Carbonate	6.656	114.109
Alumina	0.197	3.377
Silica	0.348	5.966
Total	58.398	1001.169

As will be noted the analysis indicates considerable difference in the mineral content of the two springs. Some of the other springs are said to differ from these.

NEWPORT.

Newport is on the west bank of the St. Marks River. The water supply is from the Newport Springs. This was at one time a well-known health resort but at present only a few houses remain at the locality. The water from the springs is very clear and is reported to have medicinal qualities. The following is an analysis made in the office of the State Chemist, A. M. Henry, Analyst, of a sample of this water, sent in by Mr. Nathaniel Brewer, Jr.

Constituents.	Parts per Million.
Chlorine (Cl)	18.
Carbonate radicle (CO_3)	0.
Bicarbonate radicle (HCO_3)	216.
Loss on Ignition	70.
Total dissolved solids	342.

JEFFERSON COUNTY.

LOCATION AND SURFACE FEATURES.

Jefferson county extends from the Georgia-Florida line on the north to the Gulf of Mexico on the south. The Aucilla River forms most of its eastern boundary, separating it from Madison and Taylor counties. Leon and Wakulla counties bound it on the west. The total area is 593 square miles or 379,520 acres.

The general surface features, soils and drainage of Jefferson county have much in common with the adjoining counties on the east and west. Approximately two-thirds of the county, the northern part, consists of the rolling red clay hill type of country, while the southern part consists of more level land. This northern portion is interspersed with several lakes, the largest of which is Lake Miccosukee in the northwest corner. This lake receives a large part of the run-off of this section. It is drained through solution cavities into the porous limestones which lie comparatively close to the surface over most of the county. Many limestone sinks occur throughout the county and the Aucilla River on the east has a succession of "sinks" and "rises" throughout its course.

ELEVATIONS.

Although no exact levels have been made in Jefferson county the several railroad surveys that have been made give approximately the elevations of the leading towns. The following are given for towns on the Seaboard Air Line: Aucilla 86 feet; Drifton 133 feet; Lloyds 85 feet. Wacissa, in the south-central part of the county, is said to be 45 feet above sea.* According to levels made by the Atlantic Coast Line Railroad the depot at Monticello is 202 feet above sea.

The two largest streams in the county are the Aucilla River on the east and the Wacissa River in the southern part. These rivers with their several tributary streams carry off the surface drainage. Aside from the drainage by surface streams this county has a well defined system of underground drainage. Lake Miccosukee occasionally becomes dry, the water passing off through the sink near the northwest corner. The principal surface outlet of this lake is through a small stream near the south end of the lake. This stream likewise enters a sink about two miles south of the lake. Mill Creek, which flows in from the south, disappears through a sink only a short distance from the one into which the stream from Lake Miccosukee drains. In seasons of heavy rainfall when these sinks are unable to carry off all water the two streams over flow into the St. Marks River on the southwest.

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*U. S. Department of Agriculture, Advance Sheet, Field Operations of the Bureau of Soils, Soil Survey of Jefferson county, Florida, p. 6, 1908.

ARTESIAN WELLS.

Flowing artesian wells have not been obtained in Jefferson county. The deep wells of the northern part of the county are of the class of non-flowing artesian wells. In the southern part of the county where the surface elevation is reduced it is possible that a flow could be obtained from a depth of several hundred feet. although no test well has been drilled. The water from flowing wells if obtained along the Gulf coast of this county would probably be relatively high in mineral constituents.

LOCAL DETAILS.

AUCILLA.

There are no deep wells at Aucilla. The surface formation here includes sand and sandy clays. Surface wells from 30 to 40 feet deep terminate in these sandy clays and furnish an ample supply for all general purposes.

LAMONT.

Lamont is in east-central Jefferson county near the Aucilla River. Open dug wells ranging in depth from 20 to 30 feet are common at this locality. Wells of this depth furnish a good supply of soft water which is found in a sandy clay formation. There is one deep well here, however, which terminates in a limestone at a depth of 132½ feet. The limestone was encountered at the depth of 129 feet. This well is two inches in diameter and is cased to the rock. It was drilled by G. P. Payne in 1908. The water rises to within 13 feet of the surface.

MONTICELLO.

Monticello is located in the north-central part and is the county seat of Jefferson county. The elevation as given by the Atlantic Coast Line Railroad at the depot here is 202 feet above sea. The city is supplied with water from two wells, one 400 and the other 800 feet in depth. The 800 foot well is eight inches in diameter and is cased 300 feet. The elevation of this well is approximately the same as that at the depot. The water is said to stand 150 feet below the surface. The water is hard and when used in boilers forms a hard incrustation. The second well is six inches in diameter and is cased 150 feet. The well is said to have the same head as the 800 foot well and to furnish the same quality of water.

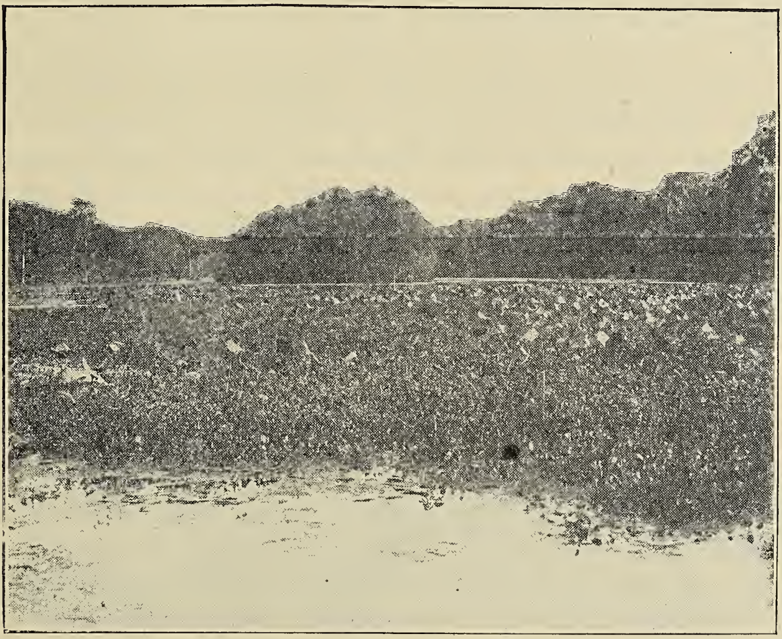

Fig. 14.—Wacissa Spring in Jefferson County.

WAUKEENAH.

Waukeenah is in the central part of the county. It lies within the rolling sandy clay soils and consequently the need for deep drilling in order to obtain a good water has not been felt. The water here is obtained from wells varying in depth from 20 to 60 feet which terminate in this sandy clay formation and furnish a good supply of soft water.

MADISON COUNTY.

LOCATION AND SURFACE FEATURES.

Madison county extends north to the Georgia-Florida line. Its eastern boundary is formed by the Withlacoochee and Suwannee rivers which separate it from Hamilton and Suwannee counties. On the south it is bounded by Lafayette and Taylor counties, and on the west by Taylor and Jefferson counties. The Aucilla River makes up a part of this western boundary. The total area is 693 square miles or 443,520 acres.

The western half of this county consists of the rolling red sandy clay type of soils resembling the contiguous parts of Jefferson county. The eastern half is gently undulating. This section may be correlated with the western parts of Hamilton and Suwannee counties. In the vicinity of Lee and along the rivers in this eastern section limestone sinks and springs occur. The southern part of the county is more level. The principal growth on the red hills consists of hardwood timber while in more sandy regions, the long leaf pine is the prevailing tree. Southward in the flatwoods part of the county the prevailing growth is long leaf pine.

ELEVATIONS.

The following elevations are recorded at stations along the Seaboard Air Line Railway which crosses the central part of the county from east to west: Ellaville (near Suwannee River) 64 feet; Lee 96 feet; West Farm 107 feet; Madison 133 feet; Greenville 106 feet. No records along the other railroad lines in this county have been obtained.

DRAINAGE.

The Aucilla River on the west and the Withlacoochee and Suwannee rivers on the east make up the drainage system of the county. The intervening country slopes to these two rivers which carry off a great portion of the surface drainage. In the eastern part of the county many sink holes occur. The rivers here have also cut their channels into the underlying limestone. The drainage is in part through these sink holes into the limestones.

ARTESIAN WELLS.

A number of wells have been drilled in Madison county ranging in depth from 100 to 400 feet. These are non-flowing artesian wells. Flowing wells have not been obtained in this county.

LOCAL DETAILS.

ELLAVILLE.

Ellaville is in eastern Madison county on the Seaboard Air Line Railway at the junction of the Withlacoochee and Suwannee Rivers. The elevation of the depot here is 64 feet above sea. Limestone lies very close to the surface at this locality and wells of only moderate depth yield hard water. The artesian wells average about 100 feet in depth and the water rises to within about 35 feet of the surface. Mr. R. L. Millinor owns a three inch well located near the depot which is about 100 feet deep. Limestone rock was encountered at the depth of 12 feet and the water rises to within 35 feet of the surface or 29 feet above sea, The elevation of the well being practically the same as that of the depot. This is a typical artesian well of this vicinity.

GREENVILLE.

A well drilled here for Mr. J. W. Bishop reached a depth of 205 feet. It is two inches in diameter and is cased 200 feet. The water is said to stand about 12 feet below the surface. The well was drilled for the purpose of draining a small pond.

Records of two other wells have been obtained from Greenville. These wells are two inches in diameter. One is 99, and the other 104 feet in depth. The water, which is hard, is said to rise to within 60 feet of the surface.

LEE.

Several wells have been sunk here, the deepest one on record, however, being only 108 feet. Many limestone sinks occur in this section and the rock lies comparatively near the surface, and it is not necessary to drill a great depth in order to reach the underground waters. The wells are mostly two inches in diameter and range in depth from 65 to 108 feet. The water, which is hard, stands from 40 to 50 feet below the surface depending on local surface variations.

LOVETT.

Lovett is in northwestern Madison county near the boundary line of Jefferson county. A two inch well was drilled here in 1906 by Mr. G. P. Payne. It is 100 feet deep and is cased 90 feet at which depth rock was encountered. The water is said to stand 46 feet below the surface.

A well 3 miles east of Lovett was drilled for Mr. D. M. Wood by Bond and Payne in 1907. This is a two inch well, 145 feet deep and cased 142 feet. Rock was said to have been encountered at 125 feet. The water stands 130 feet below the surface. An analysis of the water from this well by the State Chemist shows the total solids to be 180.5 parts per million parts water. These solids are reported to be composed principally of calcium carbonate (lime), sodium chloride (salt), magnesium sulphate (epsom salts), and silica.

MADISON.

Madison, the county seat, lies near the central part and is the largest town in the county. The surface material here is the rolling red sandy clays. The elevation at the Seaboard Air Line depot here is 133 feet above sea. An artesian well 400 feet deep and owned by the Madison Electric Power Company supplies the city with water. The well is cased to a depth of 64 feet with 10-inch casing and with 8-inch casing to a depth of something over 100 feet. Below this depth the well is reduced to four inches in diameter and is cased with 4-inch casing to 221 feet. The water rises to within 90 feet of the surface. The first rock is said to have been encountered at 64 feet, the line of 10-inch pipe being imbedded on this rock. An analysis of this water by the State Chemist shows it to contain 174 parts solids to 1,000,000 parts water. These solids are reported to be composed principally of calcium carbonate (lime), sodium chloride (salt), and iron oxide.

Several deep wells have been drilled in the vicinity of Madison for the purpose of draining swamp and overflowed lands, and with good success. These range in depth from 60 to 128 feet. In size they range from two to six inches.

RED OAK.

Red Oak is in extreme southwestern Madison county. Wells ranging in depth from 61 to 78 feet were drilled here by G. P. Payne in 1904. The water, which stands from two to three feet below the surface, is slightly hard.

SIRMANS.

Sirmans is in the southern part of the county. The shallow wells are mostly in use at this locality. However, deeper wells have recently been sunk. A record has been obtained of three of the deeper wells which range from 87½ to 125 feet in depth. They are all two inches in diameter. The water in the wells near the town rises to within about 14 feet of the surface. In the well of Mr. R. P. Henry, two miles east of town, the water stands about 30 feet below the surface. In all cases it is the characteristic hard water of the artesian wells of the county.

TAYLOR COUNTY.

LOCATION AND SURFACE FEATURES.

Taylor county joins Madison county on the north and Lafayette county on the east. The Steinhatchee River forms a part of the eastern boundary line. The Aucilla River forms the western boundary. On the south the county extends to the Gulf of Mexico. The total area is 1100 square miles or 704,000 acres.

This county has in general a level surface. Over much of the southern part of the county limestones lie near the surface and are exposed along the streams. The calcareous hammock lands found in this limestone section where not cleared support a dense growth of hardwood trees. Aside from the hammocks by far the greatest part of the county is covered by a growth of long leaf pine.

ELEVATIONS.

According to levels made by the Live Oak, Perry and Gulf Railroad the elevation at Perry in Taylor county is 30 feet above sea. No other elevations in this county have been obtained.

DRAINAGE.

The county is intersected by a great many streams the principal of which are the Aucilla,, Econfina, Fenholloway, Spring Warrior and Steinhatchee rivers. These rivers together with tributary branches form the drainage system of the county. Several large springs, the water from some of which have medicinal qualities, are found in this county. The best known of these is Hampton Springs on Rocky Creek, a tributary of the Fenholloway.

ARTESIAN WELLS.

A flowing artesian well yielding a mineral water has been obtained at Perry in Taylor county at a depth of 1207 feet. The more shallow wells of the county are non-flowing artesian wells.

LOCAL DETAILS.

HAMPTON SPRINGS.

Hampton Springs is located in Taylor county about five miles southwest of Perry. The spring at this place, known as Hampton Springs and owned by the Hampton Springs Hotel and Mineral Water Company, flows about 223 gallons per minute. The following is an analysis of the water from the spring made by H. K. Miller, Professor of Chemistry, University of Florida, 1904:

Constituents.	Parts per Million.
Total solids	985.0
Volatile matter	155.0
Silica	7.0
Magnesium sulphate	365.2
Calcium sulphate	210.5
Calcium bicarbonate	422.3
Sodium chloride	55.6
Potassium	0.4
Sulphuretted hydrogen	3.5

There are several other springs in this part of the county. Among these are Union Springs and Waldo Springs. The flow of Waldo Springs is estimated to be 12,000 gallons per minute. The water from both of these springs is charged with hydrogen sulphide.

FENHOLLOWAY.

No deep wells are reported from Fenholloway. The shallow open dug well and driven pumps are in general use here. These average probably about 25 feet in depth.

A small spring located here is known as Fenholloway Sulphur Springs. It has a small flow and empties into Fenholloway River.

The following is an analysis of this water. Analysis made in the office of the State Chemist, B. H. Bridges, Analyst.

Constituents.	Parts per Million.
Chlorine (Cl)	70.9
Sulphates (SO_4)	640.0
Silica (SiO_2)	50.0
Calcium Oxide (CaO)	920.0
Magnesium Oxide (MgO)	420.0
Total solids	3282.0

LAKE BIRD.

Lake Bird is in the northern part of Taylor county. A two inch well was sunk here for the Dowling Park Naval Stores Company. It is 90 feet in depth and the water rises to within 5 feet of the surface. The water is hard and is said not to contain hydrogen sulphide.

A shallow well here for the Lake Bird Lumber Company furnishes soft water. It is 1½ inches in diameter and 22 feet deep.

LUTHER.

A record of one well has been obtained from Luther. It is three inches in diameter, 96 feet deep and is cased the entire depth. The well was sunk in 1904 for Powell and McLain by McMullen and Faulkner. The water, which is used for general purposes around the turpentine still, rises to within 5 feet of the surface.

PERRY.

The deepest well in Taylor county is located at Perry, the county seat. This was drilled by F. J. White and Company in 1910 for the town of Perry. The well has a total depth of 1207 feet and the diameter of the casing was reduced from 10 to 4 inches in the process of drilling. The water which rises a few feet above the surface has been piped to the city court house and is used for drinking purposes as it has been found to possess medicinal qualities. The well flows 15 to 25 gallons per minute. Mr. White states that at the depth of 1000 feet a dark colored water was obtained in which was found a considerable number of live oak leaves. Samples of this material were not preserved. Mr. White believes that the leaves were recent and had reached the well through cavities in the limestone from a surface opening. As will be noted from the log of the well the vein of water containing the leaves is shut off by the casing. The following log of this well was kindly supplied by the driller, Mr. F. J. White.

	Feet.
Dry sand	0- 12
Sand with water	12- 14
Soft limestone	14- 16
Sand and water	16- 26
Decayed limestone, boulders and with water	26- 180
Solid sand rock, very hard	180- 260
Honey combed rock containing water	260- 270
Hard, white and brown flint rock	270- 430
Honey combed rock containing water	430- 440
Gray and white flint rock, very hard, with layers of white material like chalk. Water at 543 feet	440- 590
Cavity	590- 592
Very hard solid rock	592- 596
Hard flint rock	596- 600
Honey combed rock with water	600- 606
Hard blue clay	606- 612
Hard rock. At depth of 1000 feet small stream of water with live oak leaves. 4 inch pipe put in at this depth and driven in solid rock, cutting off all water above	612-1000
Hard flint rock with streaks of white material resembling chalk. Flow at this depth from 15 to 25 gallons per minute	1000-1207

By consulting the log it will be seen that a honey combed rock (porous limestone) containing water was encountered at the depth of 600 to 606 feet. A sample of this water was drawn and sent in by Mr. White to the State Chemist for analysis. The total dissolved solids as shown by this analysis, were 302 parts per million parts water.

When the well was completed another sample sent in to the State Chemist for analysis by J. W. Cobb, Perry, Florida, showed the following content. A. M. Henry, Analyst.

Constituents.	Parts per Million.
Chlorine (Cl)	596.
Carbonate radicle (CO_3)	0.
Bicarbonate radicle (HCO_3)	156.
Loss on Ignition	770.
Total dissolved solids	5650.

The Perry Ice and Power Company owns two artesian wells. One of these is 76 feet deep. It is ten inches in diameter and the water rises to within $12\frac{1}{2}$ feet of the surface. The well was sunk in 1905 by John Cole. The water from this well is used for the manufacture of ice and for the public supply. The second well is eight inches in diameter and has a depth of about 200 feet.

Driven wells are also in use in this part of the county. These are usually two inches in diameter and average about 50 feet in depth. Limestone is encountered in the drilling or driving of these wells at a depth of from 18 to 25 feet below the surface. The water rises to within about 10 feet of the surface.

LAFAYETTE COUNTY.

LOCATION AND SURFACE FEATURES.

Lafayette county lies immediately west of the Suwannee River, this river forming the entire eastern boundary and separating it from the counties of Suwannee, Alachua and Levy. The Gulf of Mexico bounds it on the south and Taylor county on the west. The Steinhatchee River forms a part of the western boundary line. Madison and Suwannee counties bound it on the north. The total area is 1202 square miles or 769,280 acres.

The surface of the county is in general level. The extreme northern part is slightly rolling. A good growth of pine is found over most of the county. Large hammocks exist particularly in the central and southern portions. Limestone lies comparatively near the surface over the entire county, and toward the south the surface materials thin down frequently exposing the rock in the different streams and sinks.

ELEVATIONS.

Mayo, the county seat, in the northern part of the county is 69 feet above sea, Media, a few miles southwest of Mayo, is 68 feet above sea. These levels were made by the Florida Railway.

DRAINAGE.

The surface drainage of the county is largely carried off by two rivers, the Suwannee on the east and the Steinhatchee on the west. Other streams of smaller size are found throughout the county some emptying directly into the Gulf of Mexico on the south. The eastern and southern parts are dotted with many sinks through which the surface waters pass into the underlying limestones. The so-called natural wells are also of common occurrence. These are solution cavities in the limestone which are open and furnish a limestone water.

ARTESIAN WELLS.

Only a limited number of wells are reported from Lafayette county. These vary in depth from 75 to 120 feet and are non-flowing.

LOCAL DETAILS.

ALTON.

Alton lies about two miles east of Mayo in the northern part of Lafayette county. A non-flowing artesian well at this place is reported to be about 108 feet deep and to furnish hard water.

DAY.

Day is in the extreme northern portion of the county along the Live Oak, Perry and Gulf Railroad. Several wells have been drilled here ranging in depth from 65 to 85 feet. These yield hard water. The depth to the underlying limestone is reported to be about 25 to 30 feet. The wells are principally two inches in diameter and the water rises to within 40 feet of the surface.

MAYO.

Mayo is the county seat and largest town in the county. The elevation at the Florida Railway depot is 69 feet above sea. The town has a waterworks system which is under private ownership. The well from which the supply is taken is three inches in diameter and 120 feet deep. It is cased 118 feet. The water is hard and has a slight sulphur taste and odor. The location of the well is approximately five feet lower than at the depot, and the water rises to within 21 feet of the surface or about 43 feet above sea. The following is an analysis of the water from this well. Analysis made in the office of the State Chemist, B. H. Bridges, Analyst.

Constituents.	Parts Per Million.
Chlorine (Cl)	58.8
Sulphates (SO_4)	39.0
Silica (SiO_2)	90.0
Calcium Oxide (CaO)	1105.0
Magnesium Oxide (MgO)	733.2
Total Solids	2510.0

The Mayo Electric Light and Water Company own an artesian well the water from which is used for the manufacture of ice. It is a three-inch well, 73 feet deep and is cased to a depth of 70 feet.

The water, which is hard, rises to within 23 feet of the surface. The following is the analysis of the water from this well. Analysis made in the office of the State Chemist, B. H. Bridges, Analyst.

Constituents.	Parts Per Million.
Chlorine (Cl)	159.5
Sulphates (SO_4)	11.4
Silica (SiO_2)	.....
Calcium Oxide (CaO)	547.0
Magnesium Oxide (MgO)	87.7
Total Solids	1812.0

Several other wells have been drilled in and around Mayo ranging in depth from about 70 to 90 feet.

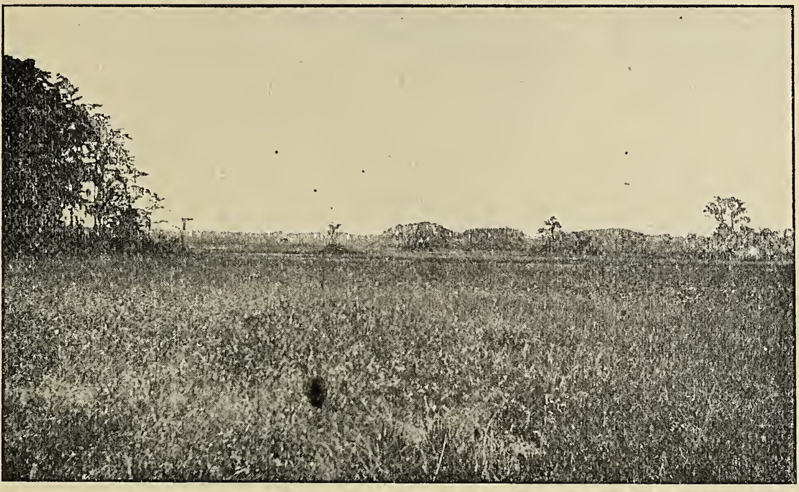

Fig. 15.—Marshy prairie about five miles east of Greenville in Madison County. Photograph by R. M. Harper.

FLORIDA STATE GEOLOGICAL SURVEY

E. H. SELLARDS, State Geologist.

PRODUCTION OF PHOSPHATE ROCK IN FLORIDA DURING 1910.

Summary of production and shipments for the year 1910.

Hard rock	Total production	392,088
	Consigned for use in U. S.	18,745
	Exported	461,353
	Total shipments	480,098
Pebble rock	Total production	1,637,709
	Consigned for use in U. S.	995,728
	Exported	606,110
	Total shipments	1,601,838
Total production of hard and pebble rock		2,029,797
Total shipments of hard and pebble rock		2,081,936

First issued as advance statement, March, 1911.

PRODUCTION OF PHOSPHATE ROCK IN FLORIDA DURING 1910.

E. H. SELLARDS, State Geologist.

The production of phosphate rock in Florida during 1910 exceeds that of any preceding year, the output having for the first time reached and passed the land mark of 2,000,000 tons. The total production for 1909 was 1,862,151 tons, while for 1910 the production was approximately 2,029,797 tons. This large output is more remarkable in view of the depressed prices for phosphate which prevailed throughout the year. The increase is due, however, entirely to the pebble section, the output of hard rock having actually decreased.

A notable feature is the fact that shipments of phosphate during 1910 exceeded the amount mined. While the output as already stated slightly exceeded 2,000,000 tons the amount shipped to domestic and foreign consignments as reported by the several companies is little, if any, short of 2,081,936 tons. This excess of shipment over production occurred in the hard rock section where the shipments exceeded the amount mined by nearly 100,000 tons, thus materially reducing the stock on hand at the beginning of the new year.

The amount of phosphate consigned for use in the United States during 1909 from Florida was 837,217 tons, while during 1910 the consignments to points within the United States was according to the reports of the producers slightly in excess of 1,000,000 tons. This is as it should be, and is an encouraging sign of the increased home demand for phosphate.

The price of phosphate rock during the year was nominal. The hard rock is said to have sold at $5 to $6 f. o. b. at mines, and the pebble at $2.75 to $3 f. o. b. at mines.

HARD ROCK.

The total number of plants operating at the beginning of the year in the hard rock section was thirty-seven. Some of these worked out deposits, or for other reasons closed down during the year, but a number of new mines opened up. The number operating at the close of the year was forty-five. Twenty companies in all were operating in the hard rock section during all or a part of the year.

The production of hard rock during 1910 as in the preceding year records a decided falling off. The amount mined during 1909 was 527,582 tons, while during 1910 the output fell to about 392,088 tons. The production for 1908, 768,011 tons, is the maximum output for the hard rock fields, and unless the phosphate market materially improves is likely to remain the maximum.

As in former years the hard rock is consigned largely to foreign markets, although the amount of hard rock used within the United States is gradually increasing. The hard rock consigned for use in the United States during 1910 was 18,745, as against 17,456 during 1909. The amount exported during 1910 was about 461,353 tons.

Pebble Phosphate Rock.

While the production of hard rock was further reduced during 1910, the production of pebble phosphate was materially increased. The amount of pebble mined during 1909 was 1,334,569 long tons. For the year 1910 the production of pebble rock amounted to 1,637,709 long tons, an increase of 303,140 tons. A proportionate increase during 1911, which is probable, will carry the production of pebble rock above 2,000,000 tons. Fifteen companies operated in the land pebble section during the year, and at least one new company is preparing to operate during 1911.

The shipments of pebble phosphate to points within the United States increased during 1910 over 1909. The consignments within the United States for 1909 amounted to 819,761. Consignments to points within the United States during 1910 amounted to about 995,728 tons. Foreign shipments for 1909 were 509,341 tons, while during 1910 foreign shipments amounted to 606,110 tons.

The statistics given above are based upon reports of production kindly supplied by the phosphate operators, and are essentially complete, although the output of two of the smaller hard rock mines on which reports are lacking are estimated. The amount exported is that shown by the export shipments from the several ports, the totals of which have been compiled by The American Fertilizer. With these returns the consignments during the year reported to the Survey by the operators substantially agree.

COMPARATIVE TABLE OF PRODUCTION AND SHIPMENT OF FLORIDA PHOSPHATE FOR THE YEARS 1908, 1909, AND 1910 (LONG TONS.)

	PRODUCTION,			Consigned for Use in the U. S.			EXPORTED.			Totul Shipments.		
	1908	1909	1910	1908	1909	1910	1908	1909	1910	1908	1909	1910
Hard Rock........	768,011	527,582	392,088	9,900	17,456	18,745	631,001	496,645	461,353	631,001	514,101	480,098
Pebble Rock.......	1,150,000	1,334,569	1,637,709	421,781	819,701	995,728	470,270	509,341	606,110	900,519	1,329,102	1,601,838
Totals	1,918,011	1,862,151	2,029,797	431,681	837,217	1,014,473	1,101,271	1,005,986	1,067,463	1,531,520	1,843,203	2,081,936

PRODUCTION OF PHOSPHATE ROCK IN FLORIDA DURING 1911.

BY E. H. SELLARDS.

Summary of production and shipments during 1911.

		Long tons.
Hard rock	On hand January 1, 1911	201,499
	Mined during 1911	474,094
	Consigned for use in the U. S. during 1911	16,723
	Exported during 1911	462,072
	On hand January 1, 1912	196,592
Pebble rock	On hand January 1, 1911	227,236
	Mined during 1911	2,020,478
	Consigned for use in U. S. during 1911	1,274,056
	Exported during 1911	703,589
	On hand January 1, 1912	273,699

	Long tons.
Total amount of hard rock and pebble rock on hand Jan., 1911	428,735
Total amount of hard rock and pebble rock mined during 1911	2,494,572
	2,923,307
Total shipments of hard rock and pebble rock during 1911	2,456,440
Total amount of hard rock and pebble rock on hand Jan. 1, 1912	470,291
	2,926,731
Correction by minor discrepancies as to the amount on hand	3,424
	2,923,307

The production of phosphate rock in Florida during 1911 was again in excess of that of any preceding year. The production for 1910 was approximately 2,029,797 long tons, while the output for 1911 was 2,494,572 long tons, an increase of nearly a half million tons. The increase occurred in both the hard rock and the pebble fields, although the percentage of increase was greatest in the pebble field.

The amount of phosphate rock consigned for use in the United States showed a further decided increase. The total domestic shipments of phosphate rock during 1910 from Florida was 1,014,473 tons, while during 1911 the domestic shipments amounted to 1,290,779 tons, from which it appears that slightly more than one-half of the phosphate produced in Florida is consigned to points within the United States.

HARD ROCK PHOSPHATE.

The year 1911 witnessed renewed activity in the mining of hard rock phosphate in Florida, with the result that the output was appreciably increased over that of the preceding year. The total output of hard rock phosphate in Florida for the year 1910 was 392,088 long tons. The amount mined during 1911 was 474,094 tons. Although showing this increase, the production in 1911 does not equal that of 1909, which was 527,582 long tons, nor that of the record year 1908, which was 768,011 long tons.

The total number of plants operating in the hard rock section at the beginning of 1911 was forty-five. A number of these worked out deposits, or for other reasons closed down, while several new plants were built. The number of plants operating at the close of the year was forty-three. Fourteen companies operated in the hard rock section during 1911.

A notable feature in the development of the hard rock industry was the construction of a dam across the Withlacoochee River, as a result of which it has been possible to supply electric power to a number of the phosphate plants in Citrus and Marion Counties. With the aid of electric power and light some of the mines have been able to work day and night shifts, thereby materially increasing the output. The practice of removing overburden by hydraulics has also been extended during the year in the hard rock section, and has further facilitated the production of rock.

The domestic shipment of hard rock during 1911 was 16,723 tons, as against 18,745 tons during the preceding year. The amount of hard rock exported during 1911 as reported by the producers was 462,072 tons, as against 461,353 tons during the preceeding year. The total amount of hard rock phosphate shipped is in excess of the amount mined, indicating a further reduction of the stock on hand.

PEBBLE PHOSPHATE.

The production of pebble phosphate, which has steadily increased year by year, shows a further increase during 1911. The total output for 1910 was 1,637,709 long tons. The output for 1911 was 2,020,477 long tons, thus verifying the prediction of a year ago that the production of pebble rock during 1911 would exceed 2,000,000 tons. Seventeen companies operated in the pebble phosphate fields, although only sixteen were actually producing rock during 1911.

The domestic shipments of land pebble rock during 1911 amounted to 1,274,056 tons, as against 703,589 tons exported, thus contrasting with the hard rock phosphate practically all of which is exported. The domestic shipments of pebble rock during 1910 amounted to 995,728 long tons, while the amount exported was 606,110 long tons. These figures indicate an increased percentage of rock remaining in the United States.

The statistics on the production and shipments of phosphate rock have been supplied direct by the producers, and are complete for all plants operating in Florida.

Thirty-one companies in all were engaged in mining phosphate in Florida during 1911. In addition to these the Amalagamated Phosphate Company began the construction of a plant for the production of pebble phosphate.

LIST OF PHOSPHATE COMPANIES OPERATING IN FLORIDA DURING 1911.

NAME OF COMPANY.	ADDRESS.
Armour Fertilizer Works	Bartow, Fla.
Peter B. and Robert S. Bradley	92 State St., Boston, Mass, and Floral City, Fla.
J. Buttgenbach and Company	Holder, Fla.
Camp Phosphate Company	Ocala, Fla.
Central Phosphate Company	Dutton, Fla.
Charleston (S. C.) Mining and Manufacturing Company	Charleston, S. C., and Ft. Meade, Fla.
Compagnie Generale des Phosphates de la Floride	Pembroke, Fla.
Coronet Phosphate Company	Lakeland, Fla., and 99 John St., New York.
Cummer Lumber Company	Jacksonville, Fla., and Newberry, Fla.
The Dominion Pphosphate Company	Bartow, Fla.
The Dunnellon Phosphate Company	Rockwell, Fla.
Dutton Phosphate Company	Gainesville, Fla.
Florida Mining Company	165 Broadway, New York, and Mulberry, Fla.
Florida Phosphate Mining Corporation	Norfolk, Va., and Bartow, Fla.
Franklin Phosphate Company	Newberry, Fla.
Germofert Manufacturing Company	Charleston, S. C., and Jane Jay, Fla.
Holder Phosphate Company	Ocala, Fla.
International Phosphate Company	27 State St., Boston, Mass., and Ft. Meade, Fla.
Interstate Chemical Corporation	Bowling Green, Fla.
Istachatta Phosphate Company	Istachatta, Fla.
Mutual Mining Company	Savannah, Ga., and Newberry, Fla.
Palmetto Phosphate Company	Baltimore, Md. and Tiger, Bay Fla.
The Phosphate Mining Company	92 Williams St., New York, and Nichols, Fla.
Pierce Phosphate Company	2 Rector St., New York, and Pierce, Fla.
Prairie Pebble Phosphate Company	165 Broadway, New York, and Mulberry, Fla.
Schilman and Bene	Ocala, Fla.
The Southern Phosphate Development Company	Ocala, Fla.
Standard Phosphate Company	Christina, Fla.
State Phosphate Company	Bartow, Fla.
T. A. Thompson	Neals, Fla.

COMPARATIVE TABLE OF PRODUCTION AND SHIPMENT OF FLORIDA PHOSPHATE FOR THE YEARS 1908, 1909, 1910 AND 1911 (LONG TONS.)

	PRODUCTION.				Total Shipments.			
	1908	1909	1910	1911	1908	1909	1910	1911
Hard Rock..............	768,011	527,582	392,088	474,094	631,001	514,101	480,098	478,795
Pebble Rock.............	1,150,000	1,334,569	1,637,709	2,020,477	900,519	1,329,102	1,601,838	1,977,645
Totals	1,918,011	1,862,151	2,029,797	2,494,573	1,531,520	1,843,203	2,081,936	2,456,440

TABLE SHOWING FOREIGN AND DOMESTIC SHIPMENT OF FLORIDA PHOSPHATE FOR THE YEARS 1908, 1909, 1910, AND 1911 (LONG TONS.)

	Consigned for Use in the U. S.				EXPORTED.			
	1908	1909	1910	1911	1908	1909	1910	1911
Hard Rock..............	9,900	17,456	18,745	16,723	631,001	496,645	461,353	462,072
Pebble Rock.............	421,781	819,701	995,728	1,274,056	470.270	509,341	606,110	703,589
Totals	431,681	837,217	1,014,473	1,290,779	1,101,271	1,005,986	1,067,463	1,165,661

PRODUCTION OF FULLERS EARTH IN FLORIDA DURING 1910 AND 1911.

By E. H. Sellards.

The mining of fullers earth in Florida continued without notable change during 1910. The plant of the Southern Fullers Earth Company, which had been working for some years a few miles east of River Junction, on the Seaboard Air Line Railway, was moved to a new locality on the Georgia, Florida and Alabama Railroad, near Havana. This company and the fullers earth business of the Owl Commercial Company at Quincy were combined during the year, and reorganized under the name of the Floridin Company.

The Atlantic Refining Company plant at Ellenton, in Manatee County, continued operations during the year. The combined capacity of the plants now operating in Florida is about 20,000 to 30,000 short tons annually. A detailed description of the fullers earth deposits of Florida was given in the Second Annual Report of the Florida Geological Survey, pages 251 to 291, 1909.

While fullers earth serves various minor purposes it is used chiefly to clarify mineral and vegetable oils. It is a clay, and occurs in beds or strata. After being mined it is dried and ground. For mineral oils the earth, ground to 60 mesh or finer, is placed in a long cylinder. The crude oil is allowed to percolate slowly through the earth. The first oil that emerges is nearly water white, the color deepening as the process continues until the fullers earth is spent. For treatment with fullers earth the vegetable oils are heated above the boiling point of water. Fullers earth to the amount of 5 to 10 per cent of the weight of the oil is then added and the mixture thoroughly stirred, after which the oil is filtered off through bag filters. The use of American fullers earth for clarifying vegetable oils is increasing.

The total production of fullers earth in the United States during 1910 as reported by the United States Geological Survey was 32,822 short tons, of which Florida produced 18,832 short tons. The average price of fullers earth during 1910 was $9.04 per short ton. The total amount of fullers earth imported into the United States during 1910 was 16,857 short tons, valued at $132.545.

The following table of production of fullers earth in the United

States is taken from the report on The Production of Fullers Earth in 1910 by the United States Geological Survey:

PRODUCTION OF FULLERS EARTH IN THE UNITED STATES IN 1910, BY STATES, IN SHORT TONS.

STATE	Number of Operating Producers Reporting.	QUANTITY.	VALUE.	Average Price Per Ton.
Arkansas	4	2,563	$29,137	$11.37
California and Colorado	3	568	8,085	......
Florida	3	18,832	170,267	9.04
Georgia, Massachusetts and South Carolina	4	9,995	77,638	......
Texas	3	864	8,582	9.93
Total	17	32,822	$293,709	.895

PRODUCTION OF FULLERS EARTH DURING 1911.

During 1911 the Floridin Fullers Earth Company continued the operation of two plants in Gadsden County, one at Quincy and one at Jamieson. A new plant, The Fullers Earth Company, was built and began operating during 1911 at Midway, in Gadsden County.

In Manatee County the Atlantic Refining Company mined as in former years at Ellenton. The Florida Fullers Earth Company, also near Ellenton, operated during a part of the year. The total production during 1911 in Florida approximated 25,000 short tons.

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ERRATA.

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In explanation of figure 1, plate 6, for Pine land near Juliette in Marion County, read, Exposure of hardpan in Nassau County	5
In explanation of figure 1, plate 1, in place of the legend given, read Exposure of the Ocala Limestone in pit of the Florida Lime Company near Ocala	16
For degredation, read degradation	34
Insert foot note as follows: Soil Survey of Jefferson County, Fla., p. 18, 1908	36

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